for . . .

engineers and contractors controlling the design, specification, installation and maintenance of heating, ventilating and air conditioning.

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The Air Conditioning Monthly

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OUR COVER PHOTOGRAPH

Thousands of cowl ventilators, such as these, destined for 10,000 ton Liberty cargo ships, are being fabricated by the Weber Showcase and Fixture Company at Los Angeles.

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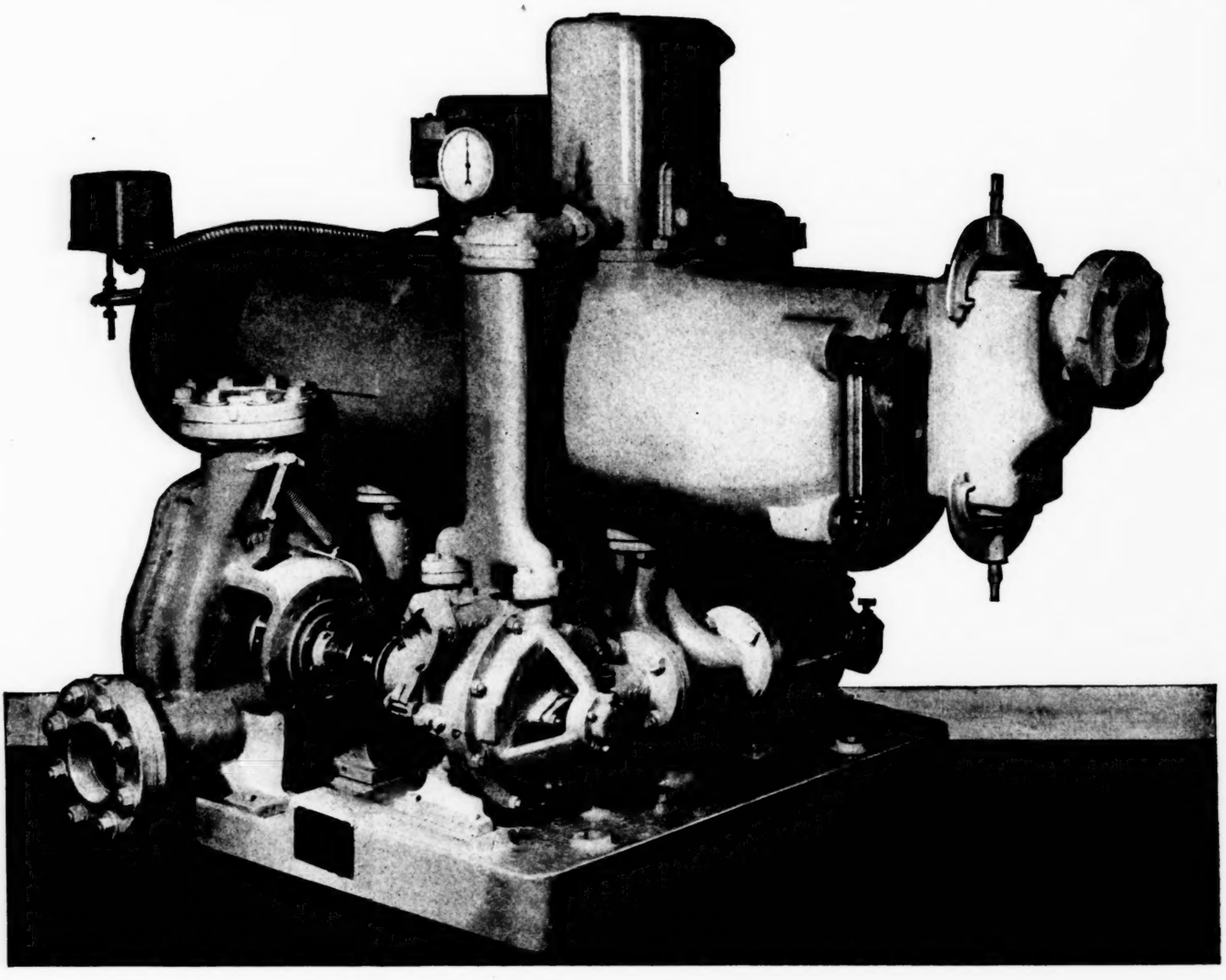
Where building heat *MUST NOT FAIL* always specify the Nash Vapor Turbine



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In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is entirely independent of electric current failure, and continues to operate as long as there is steam in the system.

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THE NASH ENGINEERING COMPANY

239 AS. WILSON ROAD • SOUTH NORWALK, CONNECTICUT • U. S. A.

Trucks and Tanks Kept Rolling

by Army's mammoth new motor repair base. Modern heating and ventilating system facilitates quick repairs to mechanized equipment.

JUNE of this year witnessed the completion and the placing in operation for the United States Army of one of this country's largest motor vehicle repair bases. So huge is one of the group of buildings, the maintenance shop, that any of the major league baseball parks could be set down inside it with room to spare.

In this giant building, equipped with all the latest automobile repair devices, will be overhauled damaged trucks, jeeps and other U. S. Army vehicles. Located in one of the New England States, the entire plant will serve the northeastern area of the country. Other areas will be similarly served by plants of the same general type, some of which are now under construction. In addition to the maintenance and repair shop, there is a huge warehouse; and other buildings include barracks, a recreation building and other smaller utility buildings for the soldier-mechanics who will do the servicing. The approximate cost of this motor repair base is said to be $1,750,000.

The rebuilding of units such as engines, axle assemblies and transmissions will be handled on a production line basis in one section of the building.

The maintenance shop covers approximately six acres and the warehouse two and one-half acres. Both are one-story, approximately 25 ft high with asphalt gravel roof over heavily bolted trusses of Oregon fir set on concrete columns. There are 13 monitors, each 440 ft long, on top of the maintenance shop and one monitor, 520 ft long, for the warehouse, which is a separate detached building. There is ample artificial lighting, including 1144 large size fluorescent lamps and 1342 300-watt drop ceiling lights. Windows run from near the eaves to within four feet of the floor, on all sides.

Five hundred trained motor mechanics, some of them civilians, will work under officers in the maintenance shop and a third as many more will be on duty in the warehouse for reception and issue of parts and accessories required in repairs. The boiler room crew will all be civilians. The official title of the group is the Quartermaster Motor Base.

The Boiler Plant

Heat is furnished through a well-designed, practically automatic system, from a central boiler plant that supplies heat to the maintenance shop and, by underground mains, to the warehouse. The design provides for an overall efficiency closely approaching that of power plants of comparable size.

Steam is provided by four firebox-type return tubular steel boilers on 5 ft brick bases, fired by Riley stokers. Each boiler is rated at 178 hp. Stokers are the single retort, double side dump, hydraulic drive, ram feed type, and are driven by 5 hp constant speed motors direct-connected to the forced-draft fan shaft, with the oil pump, mounted on the

Fig. 1. Exterior of the 6-acre maintenance and repair shop. One of the 13 monitors is shown. This one-story building of red brick with roof trusses of Oregon fir is located adjacent to a railroad siding running into the grounds of the fort.

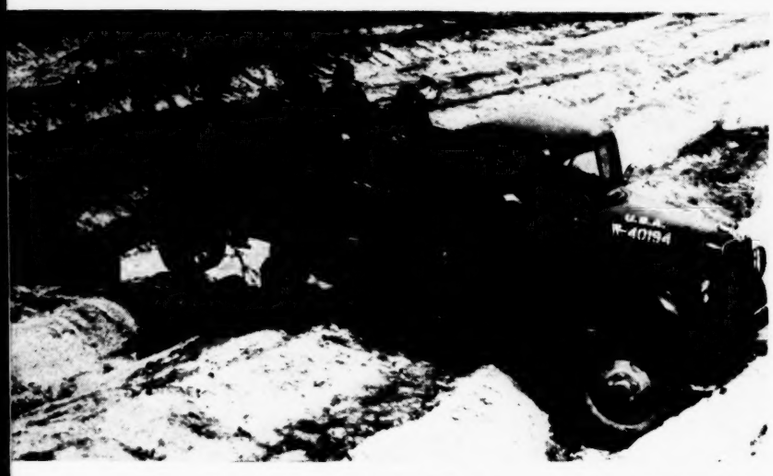


Fig. 2. View of a caterpillar type truck showing the severe conditions which this type of equipment has to meet.

Fig. 3. Showing the four 178 hp heating boilers with automatic stokers.

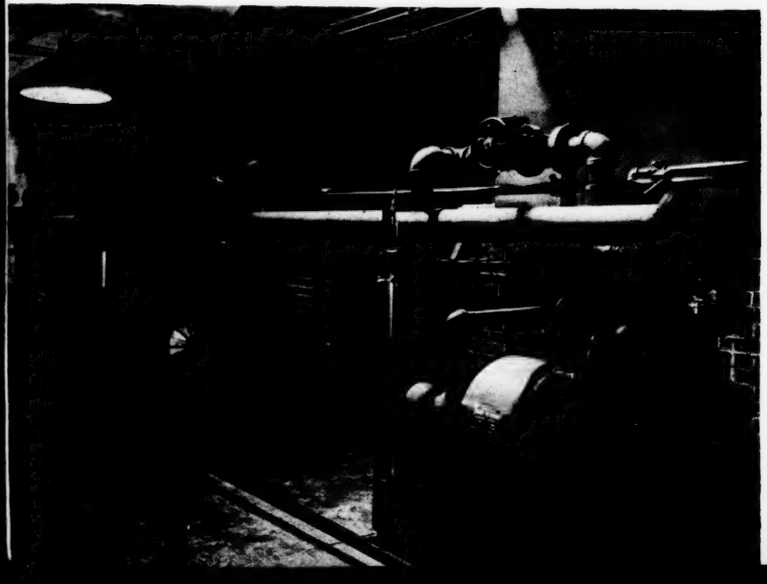


Fig. 4. Forced draft fans at rear of boilers. Each fan is driven by a 5 hp constant speed motor direct connected to the forced draft fan shaft, with oil pump mounted on the fan base, driven by the same motor.

fan base, driven by the same motor. Each of the fans has a vortex type inlet damper arranged for automatic control, and each stoker has a magnetic starting switch with push button and pilot light, all mounted in battery back of the boilers.

Proper relation between coal feed and air supply is maintained by a master regulator, actuated by header pressure, the regulator governing a counter shaft which in turn controls, through rigid linkage, the vortex damper at each forced draft inlet, and the oil feed to the stoker ram. There is a furnace pressure regulator for each boiler which, through a power cylinder, actuates the uptake damper in the smoke outlet. Each power unit can be individually operated by hand if desired.

Motive power for the control equipment is provided by an automatic motor driven oil hydraulic pump set. On one wall is an illuminated instrument board with steam, return, water pressure gages and air pressure gages for temperature control. With these, also on the board, are a three-pointer draft gage for each boiler, a pyrometer and an individual type CO_2 gage for each boiler, together with a dial type thermometer for each of the two 1000 gal hot water tanks that supply the building for all purposes. Gas sampling units, one for each boiler, for CO_2 are mounted on the brick wall back of the boilers.

Steam distribution is by a low pressure supply and vacuum return, with the supply system divided into four separate mains—one for the warehouse through the underground pipes; one to the south and east sides of the maintenance shop floor units; one for the maintenance shop overhead units; and the fourth to the west side of the shop for floor units. Each line is separately valved at the point where it leaves the main header, which is 16 in. in diameter. Three of the branches are 10 in. and one is 8 in. in diameter. A duplex motor-driven Nash pump in the boiler room brings back the returns, discharging the condensate directly to the boilers; each boiler has an automatic feed for water make-up.

The Heating System

Large capacity Dunham unit heaters of the Thermadjust type, designed for continuous operation, heat the maintenance shop. In the warehouse are both floor type unit heaters and smaller projection type overhead units, the latter for the offices and toilets. Each heater is equipped with a thermostatically-controlled by-pass damper. Ceiling units in the offices are controlled by automatic electric thermostats and three-way switches for on, off, or automatic operation. There are 18-floor units in the

Fig. 5. General view interior of the 6-acre maintenance shop. Only portion of the total floor space is shown, but an idea of the size and depth of the structure can be gained. Wooden trusses resting on Y-concrete pillars support the ventilating equipment and roof structure.

maintenance shop. A push button control for each of the heating units is mounted on a column near each unit.

Temperature control is by a Minneapolis-Honeywell pneumatic system with duplicate air compressors and air storage tanks in the boiler room. Air from these compressors provides for operation of the dampers in each unit heater and also for the automatic operation of control dampers in the exhaust ventilating system.

Ventilation of the Maintenance Shop

There are seven separate exhaust systems for the maintenance shop mounted on platforms in the trusses. Four of them serve the main repair and machine shops and one each the testing room, paint shop and dynamometer shop. These exhausts are controlled by push button stations that actuate magnetic switches on columns near each exhaust fan. When operating, any one of the exhaust systems automatically opens the fresh air damper in a corresponding unit heater. Each exhaust fan has a pneumatically-operated damper in its outboard discharge duct which is normally closed when the fan is idle.

Four of the fans have a capacity of 12,000 cfm each, one has 8000, one 5000 and the seventh has 3000. Auxiliary louver dampers are provided so that all the exhaust units may be operated in summer to remove heat from the building at ceiling level. Operation of the auxiliary louver dampers is by two-position pneumatic switches mounted on the instrument panel in the boiler room. Total heat loss for the maintenance shop is figured at 22 million Btu per hr. Interior brick walls are spray painted a light yellow adding much to the total illumination of the building which probably is the best lighted garage and repair shop in the world. Exterior walls are of red brick.

General contractor was Matthew Cummings, Boston. The heating and ventilating systems were designed by Ralph S. Franklin, division engineer of the Frank A. Barbour engineering organization. Mr. Barbour was supervising engineer. Heating and ventilating installation, including the setting of boilers, was by M. J. Flaherty Company, Boston. Other firms participating were: combustion control, A. W. Cash Company; temperature controls, Minneapolis-Honeywell Regulator Company; unit heaters and vacuum traps, C. A. Dunham Company; exhaust fans, Clarage Fan Company; stokers, Riley Stoker Company.

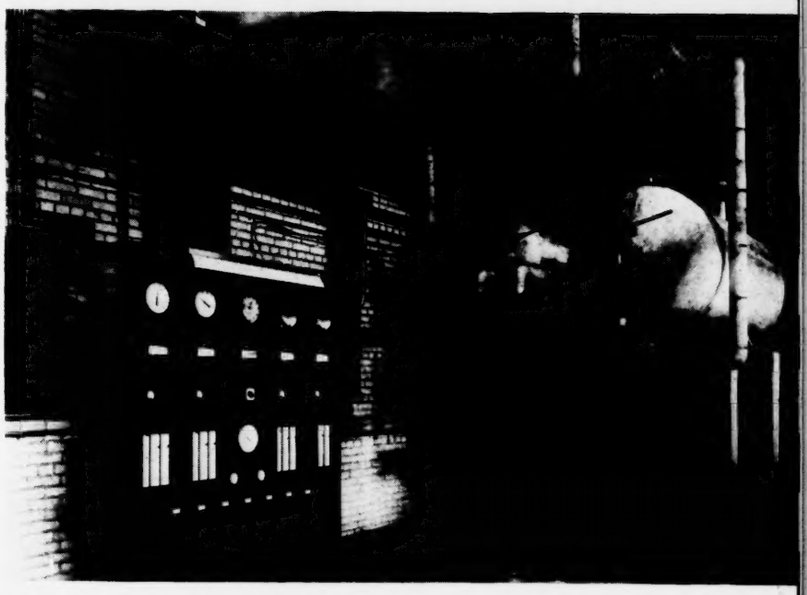


Fig. 6. Instrument board at left and two 1000-gal hot water tanks in center, mounted on concrete supports.

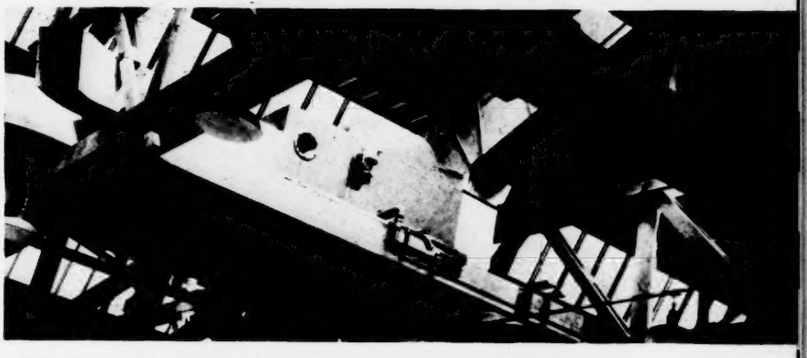


Fig. 7. One of the exhaust system units, mounted on platform in the trusses. Each exhaust fan has a pneumatically-operated damper in outboard discharge duct.

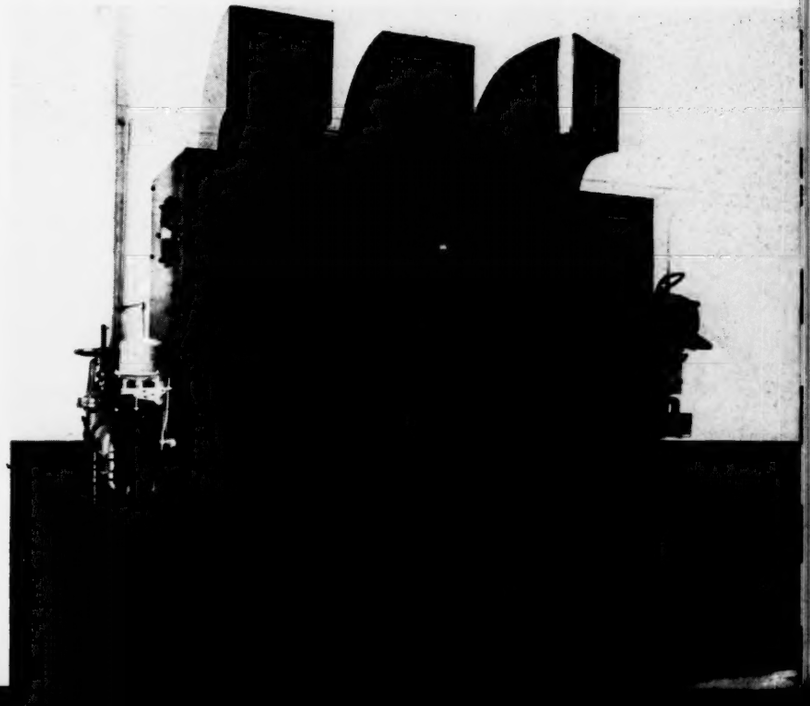


Fig. 8. A close-up of one of the two floor type unit heaters. One of these is located at each side of the main overhead doors, these serving to temper the inrush of cold wintry air when the doors are lifted.

Theory Vs. Practice

Increasing Capacity of Undersized Boilers

By T. W. REYNOLDS

THERE are any number of things that can be checked and attended to in order to increase the output of a boiler, such as cleaning of the boiler water, boiler flues, smoke pipes (particularly if lengthy), chimney base at smoke pipe connection, repair of all air leaks at boiler base, smoke pipe and chimney, and at the joints, doors and pipe openings in the boiler jacket, and providing a lower connection to the chimney for the smoke pipe from coal water heater or a separate flue for coal or gas water heater.

A draft stabilizer will keep the gases in the boiler longer, making them do more work, check the flame where the gas passages are too direct to the stack and cool off a chimney which is dangerously hot. If set in a tee at the chimney connection the stabilizer will afford a convenient cleanout to the chimney—one that is likely to be used. Draft stabilizers are commonly used with oil burning, but they are desirable on coal as well, except where the draft is too weak.

Where inadequate, chimney draft can often be improved by trying out an unused flue where one is available. Even a flue of smaller size may have a good draft for it may be higher, straighter or have fewer air leaks than the one in use, a matter which can easily be determined by burning paper in the flues in question. Two adjacent flues usually have a thin dividing wall with leakage from one flue to the other in the course of time, so that the draft is impaired in the flue that is in use. This may be overcome and the effect of a larger flue obtained by combining the two in one, simply by removal of the dividing partition at top and bottom of the chimney as far as the arm can reach. This starts the hot gases up the flue as enlarged at its bottom without favoring either flue and in the same manner prevents downdrafts which might enter the flue as enlarged at its top from selecting one flue.

The cause of inadequate draft is too often attributed to downdrafts. The mere presence of a large tree near the chimney does not necessarily mean the creation of harmful downdrafts in the chimney, as there are no leaves on the trees in the heating season except in the early fall.

In a coal burning boiler the maintenance of a higher fuel bed will often be of considerable help in increasing boiler output, since this method of firing the boiler increases the amount of live coal contact with the water backed heat absorbing surfaces. The effect is much more noticeable in a round boiler where the live coal contact is in greater proportion to the amount of coal in the fuel bed than it is in the case of sectional boilers, but irrespective of the type of boiler used, one square of surface so contacted is equivalent in the amount of heat absorption to many square feet of surface elsewhere within the boiler.

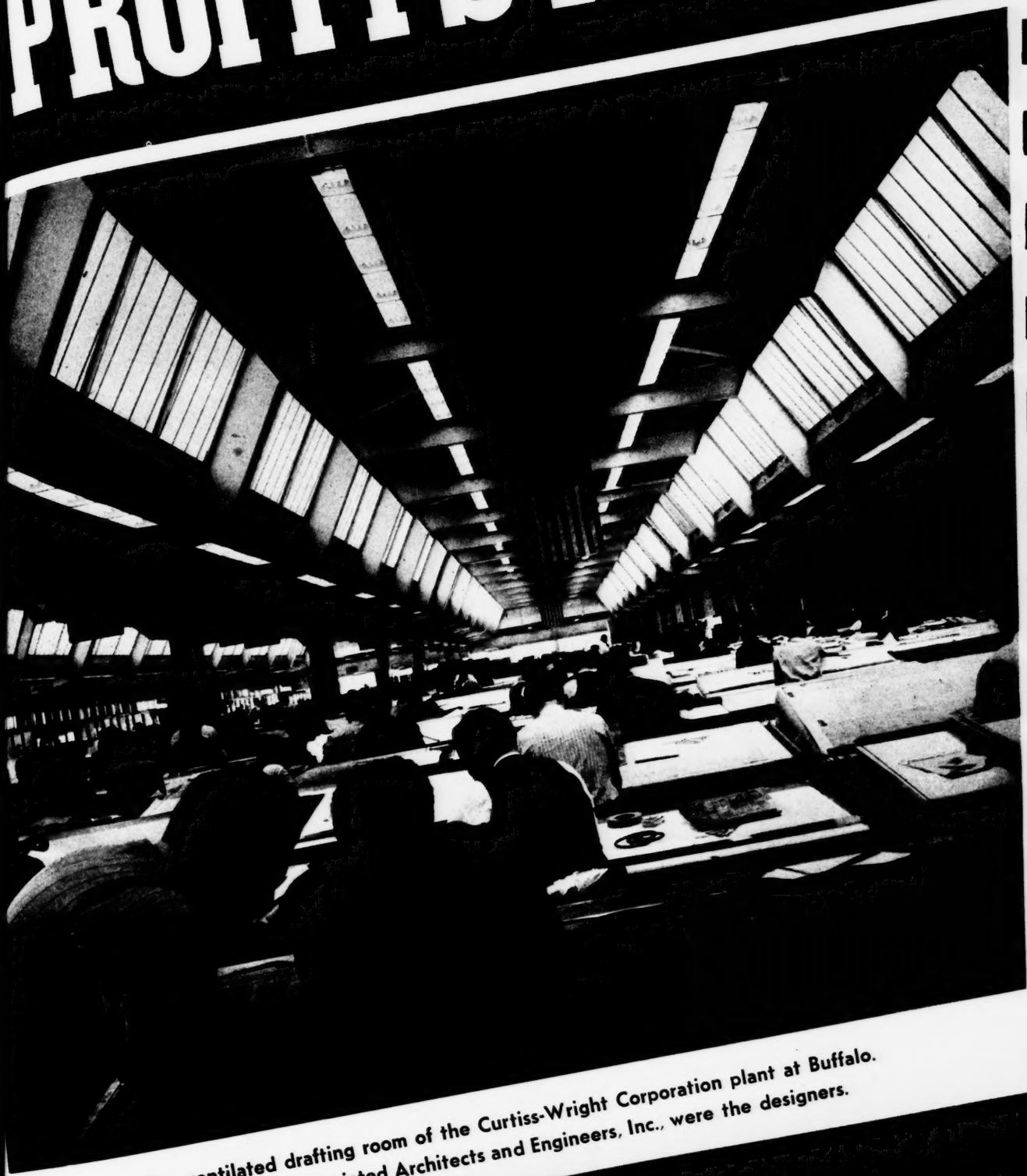
Other advantages of this method of firing is the avoidance of frequent disturbance and blanketing of the fuel bed, thin spots in the fire through which excess air would flow and frequent opening of the fuel door with consequent admission of cold air over the fuel bed. The only difficulty with this method is in convincing the average householder that he does not use more fuel by carrying a heavier fire, just as it is difficult to convince him that the grates should continue to be well shaken for some time after the first few red coals appear in the ash pit and that the clinkers must be broken up and removed or the boiler will not raise pressure or maintain a good fire.

Raising the water line on a boiler, as sometimes proposed to increase the power and efficiency of a boiler, is a disadvantage rather than an advantage, due to the reduction of necessary steam space which this practice occasions. Aside from this defect, the mains must be high enough to permit of the increased height of water line and the boiler must be of a type which provides additional heating surface as the water line rises. That is, the surfaces must have hot gases on one side and water on the other side; few boilers of today are so constructed. Raising a water line does provide an added factor of safety against the chances of a boiler water line becoming dangerously low and it is also of some value in summer water heating. However, for winter heating there is no gain in power and efficiency as boiler manufacturers have prescribed the correct height of water line for each make and type of boiler based on tests for greatest efficiency.

If the source of heat happens to be a warm air furnace instead of a boiler, then there is more often than not plenty of room for material improvement. Repair of leaks and vacuum cleaning of the furnace and ducts are of help in removing the dust which otherwise would be blown about. A filter is preferable with a fan installation, though this adds up the cost, especially so due to the large motor required.

A recirculating duct from an open stair well is a most desirable item for economy and where the furnace is under capacity it becomes a necessity, usually bringing the furnace up to requirements. The cold air duct should be removed except that any warm air which can not be returned from certain rooms must be replaced by an equal amount of cold air from outside. A recirculating duct greatly increases the pull on the warm air ducts by lessening the resistance to warm air entering the rooms which otherwise could leave the rooms only by exfiltration.

PROFITS IN AIR



The ventilated drafting room of the Curtiss-Wright Corporation plant at Buffalo. Albert Kahn Associated Architects and Engineers, Inc., were the designers.

HOW INDUSTRIAL PLANTS PROMOTE PROCESSES BY CONTROL OF AIR CONDITIONS

METALLURGICAL

FOODSTUFFS

ORDNANCE

CHEMICALS

AIRPLANES

FOUNDRIES

TOBACCO

TEXTILE

BAKERIES

ELECTRICAL

FILMS

INSTRUMENTS

GLASS

MACHINE SHOPS

PHARMACEUTICA

PLASTICS

PAPER

RUBBER

PRINTING

View on the roof over the hardening room at SKF Industries showing the twenty Allen Electri-Wind turbine ventilators. Braces, as shown, are not ordinarily applied for such ventilators but in this case were used at the request of the plant's engineering department.

SKF Industries

ventilates its hardening room by combination wind and motor driven roof ventilators, obtaining air changes once every two minutes.

By F. G. VOLZ

President, Champion Sales Company, Philadelphia, Pa.

IN a recent expansion of the hardening department at the SKF Industries considerable attention was given to the matter of ventilating the department so that undesirable fumes and gases could be removed with the objective of making working conditions not only safe but comfortable and pleasant so far as possible.

To supply this ventilation ten 30-in. roof ventilators were placed more or less equally distant on the bays over the hardening room. These units are each mechanically driven by a 1/3 hp motor. The turbines consist of backward curved centrifugal fans, unhoused, driven by V-belt drive, extended at the top of the head. The transmission is effected through a vertical shaft to an overrunning clutch so that when the motor is not in operation the ventilator is free to turn as a result of the wind action.

When there is a wind velocity of four miles per hour or over the ventilators are capable of exhausting about 4000 cfm each. In periods of no wind, or in case additional capacity is desired, the motor-driven fan is operated giving a capacity of approximately 8000 cfm for each unit.

Following the placing in operation of the original ten units over the original hardening room it was found that the operation was entirely satisfactory so that the ventilating equipment was duplicated on the new hardening room. Consequently, the total installation consists of twenty ventilators with a total capacity, when motor driven, of 160,000 cfm.

An important advantage of this type of equipment is that there is no power consumption when the demand for ventilation is not so great or when there is sufficient wind. This is particularly important in the case of the SKF installation since the plant is working on a 3-shift basis much of the time.

It was necessary to provide adequate intake for replacement of the air being exhausted by means of doors and windows on the four sides of the room. Otherwise, if some units were being motor-operated and others wind-driven, the makeup air would be short-circuited from the wind-driven units to the mechanical ventilators.

The system was developed and engineered by Alex Bletz, plant engineer of SKF Industries, and the author.

Motor Room Ventilation in Steel Mills

By T. J. ESS

Associate Editor, Iron and Steel Engineer, Pittsburgh

The motors furnishing the drive for modern steel mills have such large power consumption, undergo such severe service under extraordinarily dirty air conditions that careful ventilation for dissipating the heat with oversized air cleaning equipment is necessary. The author has ably summarized the data necessary for a ventilating engineer who may meet this type of problem.

WHETHER electrical machinery is overloaded or not is primarily a question of its temperature, regardless of the fact that the rated capacity of the machine may be exceeded. The life of insulation of the type commonly used in electrical machinery is very long at low temperatures, but drops off rapidly as the temperature rises, running perhaps ten years at 100C, two years at 110C, and only three or four weeks at 140C. Ventilation of electrical equipment is therefore a highly important factor, permitting higher loads on a given machine and contributing to its useful life.

Methods of Ventilation

The original, and still widely existent, method of ventilating electrical machinery consisted of pulling outside air through an air washer or filter into the motor room basement, from where it was forced up through the machines into the motor room. Early filters were of the hand-cleaned type, and were subsequently replaced by the continuous self-cleaning type. From the motor room the air was exhausted to the atmosphere through ventilators or louvers. This system had the disadvantage of carrying the heat into the motor room, giving uncomfortably high room temperatures. Also, in spite of high filter efficiencies, the vast amounts of air circulated carried in a considerable amount of residual dirt, resulting in maintenance for cleaning the machines. Should this dirt consist of conductive material, as typified by the carbon and metallic dusts prevailing in many parts of the steel plants, its hazard is even greater.

To eliminate the dirt deposits, closed recirculating systems were installed but, in the earlier designs, the air was forced up through all of the machines in parallel or, in some cases, up through some of the machines and down through the remaining machines. In either case, at least a part of the heat is carried into the motor room. The losses from the heavy concentration of electrical machinery in the modern motor room, however, would result in impossibly high room temperatures if ventilated in this manner. Hence, the modern installations are almost universally of down-draft circulating design, in which the warm air from the machines is discharged down into the basement, where it is cooled and returned to the motor room (Fig. 2). The low temperature thus maintained in the room is beneficial to the operation of the auxiliary equipment which is not cooled directly. The recirculating system requires a motor room and basement of tight construction in order to avoid excessive leakage.

Motor Room Layout

The layout of a motor room is naturally predicated to a considerable extent upon the layout of the mill itself. The location of the main drives is fixed by the mill designer, and the motor room is built around the motors. Where possible, a basement with about 12 ft clearance extends under the entire motor room.

Machines intended to be ventilated by a modern recirculating system should be equipped with covers so that the warm air may be collected from the machine and directed to the basement. Direct current motors and generators are usually provided with back end-shields, and the air is drawn into the machine across the commutator and down through the back end-shields into a hot air duct in the foundation, through the action of external fans. Alternating current motors draw cool air through openings around the shaft at both sides of the motor, and the hot air is discharged through an opening in the bottom of the machine frame. The construction of alternating current motors allows a design capable of providing a slight excess pressure to force air through an external cooling system, and in some cases no external fan is needed.

The foundation are designed to accommodate the necessary ducts for the ventilating system. Air barriers must be installed in the foundations to confine the heated air, and some means provided for adjustment of the heated air discharge openings, so that air flow may be balanced as required between the various machines. This adjustment need not be very fine and may be made simply by dampers installed in the openings between the machines and the ducts, or by the use of a number of small sections of plate at the openings, the air being adjusted by adding or removing small plates. The duct system is usually composed in part of the concrete foundations themselves and in part of light steel plate, and leads the heated air to the surface coolers and the fans. Thus, there is no standard practice in duct construction, almost every installation being tailored to suit local conditions. From the fans, the cooled air flows back

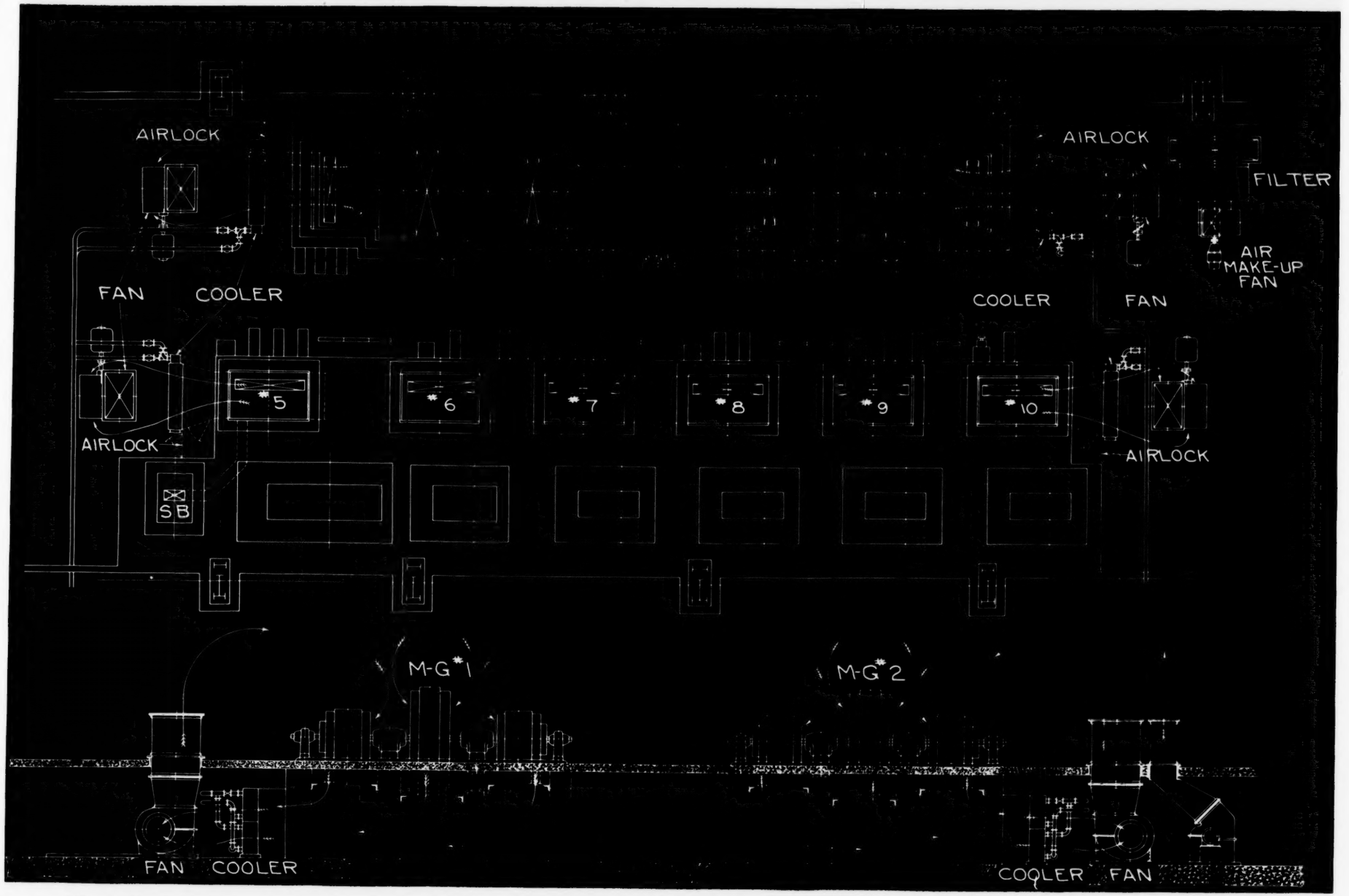


Fig. 1. Motors and motor-generator sets in a finishing train unit for a typical continuous hot strip mill, showing ventilating layout with four cooling units and four fans and make-up unit.

into the motor room, usually through several ducts exhausting into the upper part of the room along the walls. In some cases the cooled air is simply exhausted into the basement and flows up through gratings in the motor room floor, although this practice is not particularly desirable.

Heat Lost by Machines

Assuming that the motor room layout, foundation design, and motor shielding has been determined, the first item to be considered is the amount of the losses in the machines. This is primarily an electrical problem, but for those interested the method of calculation is briefly set forth.

Determination of the heat losses of the electrical machines requires a knowledge of the efficiencies of the machines and the duty cycles to be imposed on them. Naturally, the heaviest duty cycle must be used in establishing the capacity of the cooling system. If the machines carry a more or less constant load, the losses may be taken as the full load losses, using a modifying load factor should the particular application warrant. Usually, however, specific duty cycles must be used where a considerable number of machines are worked under intermittent schedules. Losses while load is being carried are estimated from the machine efficiency at the load in question, and from the duration of the load. Losses during unloaded periods are determined from the friction load and the duration of the period. The total of these losses, divided by the total duration of the cycle, gives the kw loss. In Table 1 a typical schedule of loads is set forth for a modern continuous hot strip mill. The losses are estimated for this operation and the method of their calculation is set forth. The loss as determined for this case amounts to 3150 kw. Actually, additional auxiliary equipment, exciter sets, etc., are housed in a motor room of this type, and contribute perhaps another 300 kw loss to this figure.

Ventilation per kw.

Since 1 kw is equivalent to 57 Btu per min, a total loss of 3500 kw will require a heat absorption of approximately 200,000 Btu per min. Since air, the cooling medium, will absorb about .0174 Btu per cu ft per degree F (at an average temperature of 85F), one kw loss will require 57 ÷ .0174, or 3290 cfm per degree F temperature rise. Experience has shown that electrical machines having a standard temperature rating of 40C rise are adequately served by a flow of 100 cfm per kw loss. Where a considerable number of units are to be ventilated in one room, a higher rate of flow should be used to insure a sufficiency for every unit regardless of lack of perfect balancing of the system. A figure of 120 cfm per kw of loss is frequently used for large stations. Naturally, the greater the flow the more rapidly the heat will be carried away, the lower the temperature of the machine, and the lower the temperature of the exit air. The curve in Fig. 3 shows the rise in ventilating air temperature to be expected for various rates of air circulation. It is apparent that, for motor room ventilation, a temperature rise of 25-30F is usual. Good practice further requires that air entering the machines must not be over 104F.

Air and Water Quantities

It has been found from experience with installations of this type that the air can be economically cooled down to about 10F above the temperature of the incoming water, and to several degrees lower than the exit temperature of the water. It has also been found that, in a well balanced design, a rise

TABLE 1.—CALCULATION OF LOSSES IN MOTOR ROOM
(Based on 53 sec cycle)

A	B	C	D	E	F	G	H	I	J	K
Pass	Machines	Load, Hp	Loaded Time, Sec	Idling Time, Sec	Efficiency, Per Cent	Loss, Kw		Loss, Kw-Sec		
						Loaded	Idling	Loaded	Idling	Total
1	1000	1100	5	48	95.0	41	35	205	1780	1985
2	3000	5360	5	48	95.0	200	90	1000	4310	5310
3	3000	5800	6	47	95.0	215	90	1290	4230	5520
4	3000	6900	7	46	93.5	230	85	1610	7400	9010
5	3000	5800	9	44	95.5	195	80	1755	7700	9455
6	500	500	30	23	93.0	26	20	780	460	1240
7	4500	5460	30	23	94.0	245	120	7350	2760	10,110
8	4500	4680	30	23	94.0	210	120	6300	2760	9060
9	4500	6620	30	23	94.0	295	120	8850	2760	11,610
10	4500	7400	30	23	94.0	330	120	9900	2760	12,660
11	4500	3500	30	23	93.5	170	120	5100	2760	7860
12	3000	1000	30	23	93.0	50	90	1500	2070	3570
Motor-generators	(3)6000 kw	17,000	53	—	90.0	1270	—	67,310	—	67,310
	(2)2000 kw	3000	53	—	90.0	225	—	11,925	—	11,925
										166,625

Column B—Installation data.
Columns C, D, E—Taken from maximum proposed duty cycle.
Column F—Taken from motor characteristic curves.

$$\text{Column G} = \frac{(100 - \text{column F})}{100} \times \text{column C} \times .746.$$

Column H—Taken from motor characteristics.
Column I = column D × column G.
Column J = column E × column H.
Column K = column I × column J.

$$\frac{166{,}625 \text{ kw-sec}}{53 \text{ sec}} = 3150 \text{ kw loss.}$$

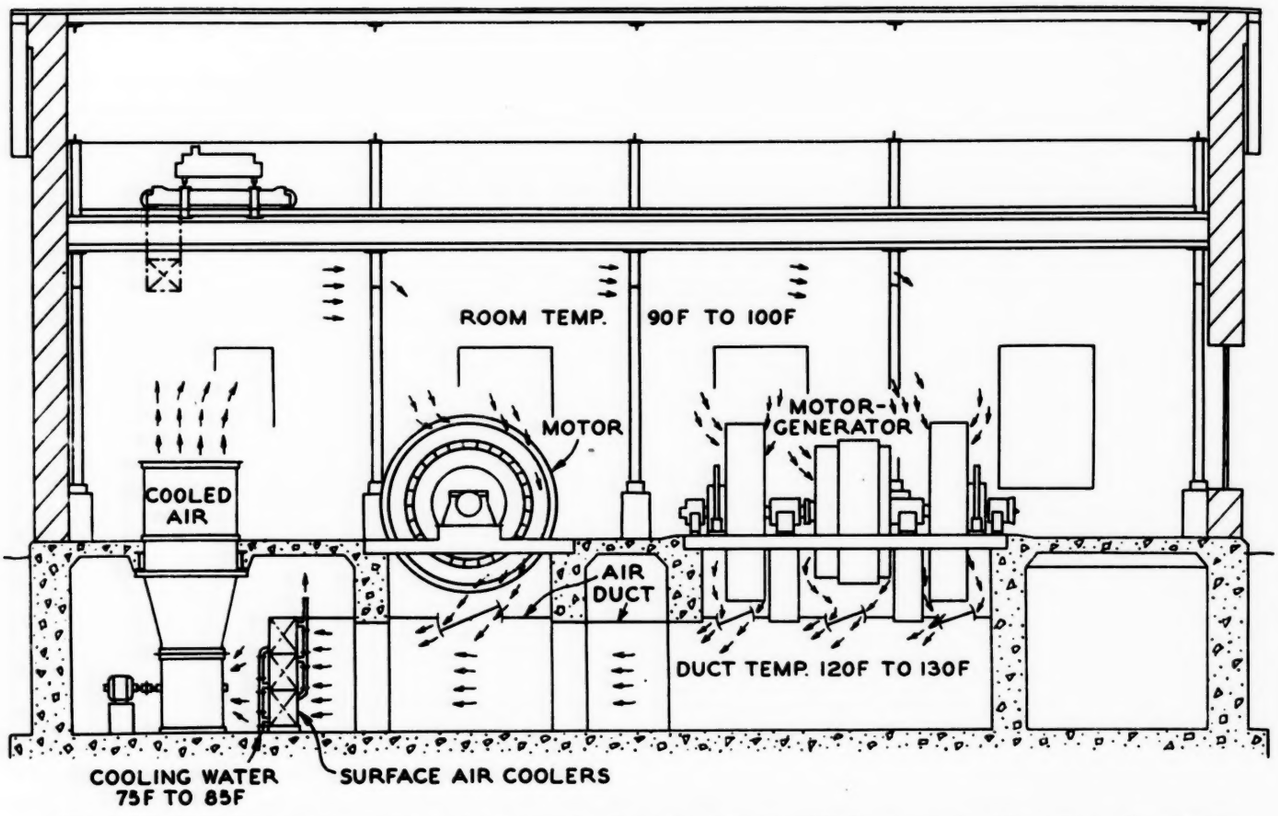


Fig. 2. Motor-generator room with typical down-draft recirculating ventilation system with surface air coolers. Vertical section showing air paths.

in water temperature of 12.5F will be obtained with the 10-degree gradient, water-to-air. On this basis, the water required per kw of loss (or for 57 Btu per min) will be 57 ÷ 12.5, or 4.56 lb per min, or .547 gpm. The 10-degree gradient, with the 104F temperature limitation on air entering the machines, imposes a maximum temperature of 94F on the incoming cooling water. Lower temperatures are desirable, however, and are fortunately usually available.

On the basis of our calculated loss of 3450 kw (including auxiliaries) the quantity of air required will be 3450 × 120, or 414,000 cfm. The fan load for recirculating this amount of air will be of the order of 280 kw, which must be included in the losses, giving a total of 3730 kw. Water requirements will then be 3730 × .547, or about 2050 gpm. To take care of possible variations in water temperature it is well to raise this figure 10 to 15%, giving a total of about 2300 gpm. An overall ratio of 1 gpm of water for each 180 cfm of air circulation is therefore indicated. Regulation of water flow in conjunction with operating loads and with water temperatures permits machine temperatures to be held at the desired point, and may be used for control of room temperature as well. The supply water should be clean and free from silt, and is, in many cases, filtered before use in the coolers. It is common practice to reclaim the water discharged from the air coolers and use it for some other purpose in the plant.

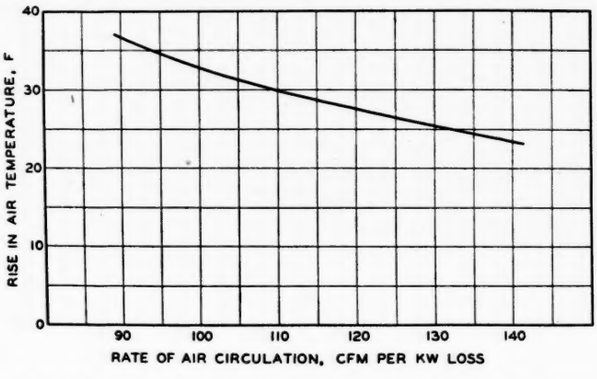


Fig. 3. Rise in ventilating air temperature for various rates of air circulation per kw.

Heat Transfer Surface

Air cooling equipment usually takes the form of surface type coolers, of fin-tube construction. The copper tubes are assembled between cast water box heads, and the increased contact surface offered by the fins gives a high rate of heat transfer. The counterflow principle is used, and the water usually makes several passes in series through the cooler, with a pressure loss of about 30 lb per sq in. The rate of heat absorption in coolers of this type may vary somewhat with the design and construction of the unit, and manufacturers' ratings should therefore be used in the selection of the cooling units. As an approximation, however, it is perhaps safe to use a transfer coefficient of 10.5 Btu per hr per sq ft

per degree F temperature difference. Thus:

$$A = \frac{H}{T_d \times c}$$

where A = cooler surface area, sq ft;
H = total heat to be absorbed, Btu per hr;
c = heat transfer coefficient (approximately 10.5 Btu per hr per sq ft per degree F); and
T_d = logarithmic mean temperature difference between air and water, degrees F, as determined by the formula:

$$T_d = \frac{(T_{a_1} - T_{w_2}) - (T_{a_2} - T_{w_1})}{\log_e \frac{T_{a_1} - T_{w_2}}{T_{a_2} - T_{w_1}}}$$

(Subscript "a" denotes air temperature; "w," water temperature. Subscript "1" denotes entry temperature to cooler; "2" denotes cooler exit temperature.)

Values from several successful installations show an average of 1 sq ft of cooler surface for every 5.8 cfm of air circulated, or about 19.2 sq ft of cooler area per kw of total loss, including fan load. The work done by the fans is transferred into heat, and the total fan load (kw input to the fan drives) should be included in the total losses of the station, as previously indicated. This may account for 2 or 3F in the temperature rise of the air, and, amounting to 8 or 10% of the machine losses, must be considered in selecting cooling equipment.

Fan Selection

As in any ventilating system, it is good practice to break up large fan capacities into two or three units. This allows flexible operation, using only part of the equipment when operating conditions or temperature permit. Fans should have a drooping volume characteristic and a flat power input curve. These non-overloading characteristics are desirable so that the fan drive motors are not overloaded when changes occur in the pressure conditions prevailing in the system.

Recirculating fans are preferably located at the exit side of the air coolers, and this arrangement is usually convenient. Should this be impossible, fan capacity should be selected with due consideration of the higher temperature of the air to be handled. Recirculating fans are usually selected with ratings at 3 to 4 in. water column static pressure.

Although a recirculating ventilation system may be theoretically closed, some leakage is unavoidable. Hence, provisions are installed for continuously introducing a small amount of clean air into the system, keeping a slight positive pressure in the motor room and preventing infiltration of dirty air from the outside. If no air is extracted from the system, the make-up capacity is usually set at 5 to 10% of the recirculated volume, with most installations favoring the higher value. If air is withdrawn from the system for cooling outlying units, such consumption must be added to the capacity of the make-up system.

Air Cleaning

As it is desirable that the make-up air be as free from solid impurities as is practically possible, the make-up air is drawn in through a cleaning unit, and it is important that this unit is not overloaded under any circumstance. Thus, it should have sufficient capacity to handle the maximum volume that the make-up fan may deliver against zero pressure. Cleaning units may consist of any of the available types, although the automatic viscous impingement type seems to prevail numerically at present. In this type, a number of overlapping filtering screens are mounted on conveying chains and form a continuous filter belt which travels slowly around, and which, at the bottom of its orbit, passes through an oil bath which washes the dirt from the screen and recoats the latter with the adhesive material.

More recently, electrostatic dust precipitation equipment has been developed for this service and has met with considerable favor. In this equipment dust particles are electrostatically charged by pass-

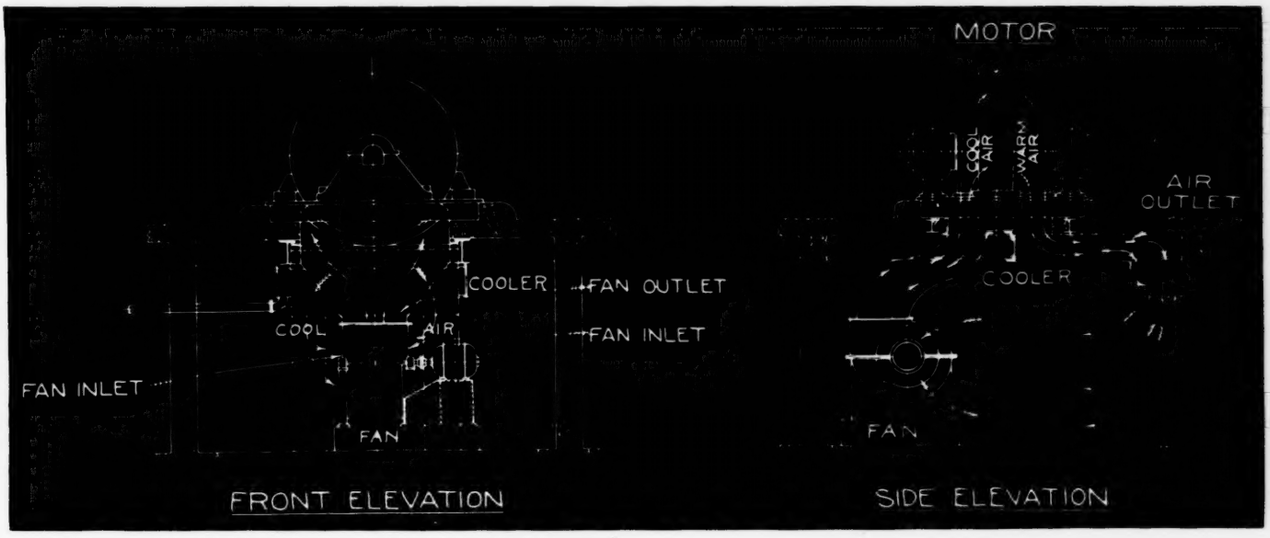


Fig. 4. Roughing mill motors are usually isolated with separate ventilating system as shown.

ing the air stream between electrodes maintained at high potential difference, and are then withdrawn from the air stream in passing through the electrostatic field created between alternately charged and grounded plates. The plates, which also act as collectors for precipitated dust, are oil-coated so that particles adhere to them. These plates must be periodically washed off and re-oiled unless the precipitator is of the self-cleaning continuous belt type design. Electrostatic equipment will remove very fine particles which slip through filters of other types. Combination units, composed of continuous impingement filters and electrostatic precipitators, have also been placed on the market.

Mechanical filters, properly designed, will remove more than 90% of the dust particles down to a size of about 10 microns, which is about the smallest particle visible to the naked eye with normal vision. This efficiency, however, drops off rapidly as particle size is reduced below this point. Electrical precipitation is effective with all sizes of particles, even down to .25 microns, showing efficiencies of 85% at the normal velocity of 500 fpm through the filter curtain, 90% at 400 fpm, and 95% at 300 fpm, as shown by the standard discoloration test method.

For steel plant service, many engineers prefer to install a filter of 25% greater capacity than might be indicated by actual filter ratings. This would mean the use of a 400 fpm air velocity through the filter curtain. Whether the filter is used only for make-up to a recirculating system or for total air supply to a non-recirculating system, the practice is the same, the only variation being in the capacity of the filter.

It is preferable that the make-up air be introduced directly into the motor room. This arrangement is usually convenient, and at the same time eliminates many possible disturbances arising from varying pressure conditions in the system. In this case a static pressure of ½ or ¾ in. water column is usually chosen for the make-up fans.

Summary of Data

Having considered the various elements of the ventilating system, let us briefly review the figures for our hypothetical case:

Total losses from machines, including auxiliaries ..... 3450 kw

Total air to be recirculated ..... 414,000 cfm

Fan load ..... 280 kw

Heat equiv. of machine losses....196,650 Btu per min.

Heat equivalent of fan load .....15,960 Btu per min.

Total heat to be absorbed ..... 212,610 Btu per min.

Temperature rise of air:

$$\frac{212{,}610}{414{,}000 \times .0174} \quad \text{..... } 29.5\text{F}$$

Volume of water required (12.5F temperature rise):

$$\frac{212{,}610}{8.33 \times 12.5} \times 1.12 \quad \text{..... } 2296 \text{ gpm}$$

With 75F water available, exit water temperature will be 75 + 12.5 ..... 87.5F

With good design, exit air temp. should be slightly less than exit water temp., say 85F

Temperature of air entering cooler is therefore 114.5F

Mean temperature difference:

$$\frac{(114.5 - 87.5) - (85 - 75}{\log_e \dfrac{114.5 - 87.5}{85 - 75}} \quad \text{..... } 17\text{F}$$

Cooler surface area:

$$\frac{212{,}610 \times 60}{17 \times 10.5} \quad \text{..... } 71{,}200 \text{ sq ft}$$

Make-up air volume, 10% of 414,000 .....41,400 cfm

Filter area (free passages), 41,400 ÷ 400 ..... 103 5 sq ft

Make-up fan, ¾ in. static pressure ..... 42,000 cfm

Splitting Installation

As previously stated, this case is typical of the modern continuous hot strip mill, wherein the various units are distributed over a motor room perhaps 60 ft × 600 ft in size. To simplify duct work and to insure proper distribution of the air, it is therefore usual to split the installation up into several sections, as may be convenient, each proportioned to the losses of the particular units served. Fig. 1 shows the finishing train units (six drive motors and their motor-generator sets) with their usual ventilating layout, using four cooling units and four fans, in addition to the make-up unit. The various machines and sections of this system must be provided with dampers or other means for insuring proper air distribution, and such adjustments should be made when the system is started, and thereafter maintained.

Roughing Mill Motors

Roughing mill motors may be cooled by another section similar to that used for the finishing train motors. However, due to the greater spaces (40 to 100 ft) separating the roughing motors, it is sometimes preferred to make each of these units a separate enclosed system, as typified by Fig. 4. Here, the air cooler, fan and ducts form a closed system which is assumed to be tight and have no exchange of air with the motor room. This illustration shows a separate fan used to recirculate the air. As previously mentioned, the a-c motors can be designed to provide the pressure for recirculating the air, but this is not always advantageous.

The recirculating system of ventilation requires an adequate supply of cool water, and should this not be available it is necessary to use a non-recirculating system, drawing all of the ventilating air from the outdoors. In such cases, large filter capacities are required, and, in order to keep motor room temperature as low as possible, the air should be brought into the motor room, passed down through the machines, collected in the basement, and expelled to the outside.

FUEL SITUATION

FRB Eases Its Credit Restrictions; OPC to Launch Conversion Campaign; ASHVE Publicizes Fuel Emergency.

The fuel situation along the Eastern Seaboard became, if anything, somewhat more confused during July. Important developments of the month included (1) announcement that OPC is preparing an intensive campaign through East Coast fuel distributors to promote oil-to-coal conversions; (2) headway was made on the Texas-Illinois pipeline; (3) tanker losses by sub sinkings are serious but rail movements of oil are increasing; (4) Ickes sharply denied that the end of the oil shortage is in sight; (5) the ASHVE called an emergency meeting of association secretaries to decide what means should be adopted to awake building owners to the seriousness of the situation; (6) a new survey by a Philadelphia oil heat distributor indicated that oil-to-coal conversion is, in most cases, impractical; this was in sharp contrast to the findings of the anthracite group; (7) the Federal Reserve Board is easing credit restrictions to encourage conversions and fuel conservation; fuel oil deliveries were further restricted from August 3 to September 15 by a WPB order.

Transportation

No data are available as to the exact number of tanks sunk. However, for the Atlantic coastal area alone there were 17 announced sinkings (all types of vessels) in January, 36 in February, 60 in March, 58 in April, 87 in May, and, according to late reports, approximately a hundred in June. July sinkings up to 10 p.m. July 27, according to Associated Press reports, were off sharply from June.

Immediate stepping-up of barge movements of oil on the inland waterways—to help meet the requirements for fuel oil and gasoline in the Atlantic Seaboard area—was called for recently by Mr. Ickes.

In a formal recommendation (No. 51 of the Coordinator) issued to the oil industry, a Joint Barge Subcommittee was authorized to suggest methods of obtaining the maximum efficiency in the use of all inland waterways barge equipment employed, and to assure that all such equipment is utilized to meet the critical problems of petroleum supply.

The subcommittee is given wide latitude in its methods of approaching the problem. The recommendation calls for two broad measures:

First: Surveys and investigations to obtain complete information concerning the "use, location, port-to-port movement, and availability of inland waterways barge equipment."

Second: The presentation of a plan to utilize present equipment most advantageously and to obtain new or converted equipment from other available sources.

A new record movement of 800,100 barrels of oil each day by rail to the East Coast was set for the week ended July 28.

A new plan to run 50 solid trains of tank cars to the East from the Southwest, with right of way over all trains except those carrying critical war material, and traveling 800 miles per day, was announced late in July.

Pipe Lines

The ground survey was completed late in July, National Tube was busy at work turning out 150 miles of pipe during July, and indications were that 160 miles of pipe would be manufactured during August for the Texas-Illinois pipe line which will consist of 550 miles of 24 in. line. This is the first leg of the Texas-East Coast line advocated by Mr. Ickes and now being built by War Emergency Pipeline, Inc. This company is an organization at 11 participating companies, as follows:

Cities Service Oil Company, Standard Oil of New Jersey, Consolidated Oil Corporation, Sun Oil Company, Atlantic Refining Company, Socony-Vacuum Oil Company, Tide Water Associated Oil Company, the Texas Company, Gulf Oil Corporation, Pan-American Petroleum and Transport Company, and Shell Oil Company.

The big line, which will have a capacity of 300,000 barrels daily, will extend from Longview, in the heart of the East Texas oil field, across the States of Arkansas and Missouri to Illinois. It will cross the Mississippi River at Thebes, Illinois, about ten miles below Cape Girardeau.

Approval of plans for the construction of an 8 in. petroleum products pipeline across northern Florida to help supply the Atlantic Coastal areas as far north as Norfolk, Virginia, was announced in July by Mr. Ickes' office.

The project, which would be built with second-hand pipe excavated in Texas, was proposed by the American Liberty Pipeline Company. That company now is negotiating financing arrangements with other Government agencies.

According to plans submitted to the Office of Petroleum Coordinator for review and appraisal, the proposed pipeline will extend from Port St. Joe on the Florida Gulf Coast to Jacksonville on the East Coast, a distance of 220 miles. Its daily delivery capacity is estimated at 35,000 barrels.

Gasoline and other products moved through the line would be transshipped by barge north and south from Jacksonville through the Atlantic Intracoastal Waterway to supply the east coasts of Florida, Georgia, South Carolina, and North Carolina.

Oil Restricted

Fuel oil deliveries on the Atlantic Coast will be further restricted until September 15, WPB has ordered at the request of OPC. The delivery control is set up by an amendment (No. 2) to Limitation Order L-56, which provides that:

1. During the period August 3-September 15, there can be no deliveries of fuel oil for the operation of heating and cooling equipment in Area One, which embraces most of the 17 East Coast States and the District of Columbia. This provision does not apply to fuel oil used for agricultural or industrial processes, or for research operations requiring temperature controls.

2. All the fuel oil to which a person is entitled for use in hot water heaters between August 3 and September 15 may be delivered in one trip, instead of several trips as heretofore. The quantity delivered may not exceed 50% of the amount used during the same period last year—August 3 to September 15, 1941.

If the amount of oil used for hot water heaters last year was abnormally high or low, or if no oil at all was used, then the supplier may deliver no more than 50% of the amount that would normally be used this year between August 3 and September 15, 1942.

Shortage End Denied

Petroleum Coordinator Ickes said July 12 there was "no foundation whatever" for recent published articles which drew the conclusion that transportation projects, now under way, would solve the present petro-

leum supply difficulties by next winter.

"Such statements as I have read," the Coordinator said, "draw the unwarranted conclusion that, by the end of the year our present problems would be over and that we would have all of the fuel oil and gasoline we need.

"On the contrary, there are now no grounds for such an optimistic view of the situation. We face a long, hard pull. The best that we can presently hope for is that arrangements already made or being made to move oil overland, plus some help from ocean tankers, will enable us to meet minimum essential requirements during the balance of the year.

"By minimum essential requirements is meant the present rationed demand for gasoline and fuel oils, deliveries of both of which are now curtailed by 50 percent. As J. R. Parten, Director of Transportation for this Office, explained in a letter dated July 7, to Senator Bailey of North Carolina, minimum rationed daily demand requirements for this calendar year total 1,367,000 barrels daily. In the first quarter of 1943, this minimum rationed daily demand will be more nearly 1,600,000 barrels daily.

"The Office of Petroleum Coordinator has under way today a comprehensive and complex program aimed at meeting this demand. Although we started practically from scratch, overland movement to the East Coast, as Mr. Parten pointed out, was at the rate of 954,000 barrels daily as of June 20. Through certain pipe line relocation projects and by increasing the use of railroad tank cars and barges, we expect to add 275,000 barrels per day to this movement by the end of the present year, giving us a total overland shipment of 1,229,000 barrels daily against a minimum rationed daily demand of 1,367,000. To balance out, with something left over to go into storage against next winter's requirements, it would be necessary to depend upon ocean movement, which no longer is either safe or certain.

"These are the facts, pure and simple. They speak for themselves. They offer no assurance that we will be back on a normal basis by the end of the year. On the contrary, they offer ample proof of the need for conservation of all petroleum products and ample reason why householders, who are now heating their homes with fuel oil, should convert to the use of coal if they can do so."

These statements were, in general, supported by R. G. A. van der Woude, president of Shell Union Oil Corp. in a second quarter report for his company in which, in reviewing the seriousness of the fuel oil situation on the east coast, he said that this is the time of the year when all oil companies build up their stocks of this product for the coming winter. This, he went on, has been impossible up to the present time due to the tanker situation, in spite of the all-out effort and the assistance from various agencies in Washington. There are not enough inland delivery facilities, he stated, such as tank cars, pipelines and barges, that can be substituted to offset this loss. To emphasize this seriousness he said that "oil companies, who have spent years to build up a fuel oil market in the eastern territory, would not be urging their customers to convert their heating units from fuel oil to coal unless the situation was of great concern." His company, he added, is doing everything possible to build up its fuel oil stock position for the winter irrespective of cost.

Further, on July 27 Joel Dean, chief of the fuel ration division of the Office of Price Administration, told a group of Congressmen that: "The shortage is not so much one of gasoline as of petroleum transportation. We are desperately short of fuel oil. We may have to shut down our war plants; we may have the people freezing to death this winter if we don't get in the fuel oil. Since every gallon of gasoline brought in by tank car displaces a gallon of fuel oil, the two are intimately connected."

His statement, one of the strongest yet made in the shortage situation confronting the East Coast, was voiced at a hearing on a protest made by business men against an OPA order which restricts traveling salesmen in the rationed area to an approximate mileage of 710 miles a month for business plus personal driving.

Other Washington comments included the following:

J. R. Parten, OPC, told a special House committee: "We must not kid ourselves. There will be curtailed consumption in this area until overland transportation is far in excess of what it is today."

Mr. Parten said daily deliveries of petroleum products by overland routes now was 938,000 barrels daily, and might soon reach 1,000,000, compared with a normal daily demand of 1,600,000 to 1,700,000.

Mr. Parten assured the committee that oil for industries and homes would have the right-of-way over gasoline in transportation.

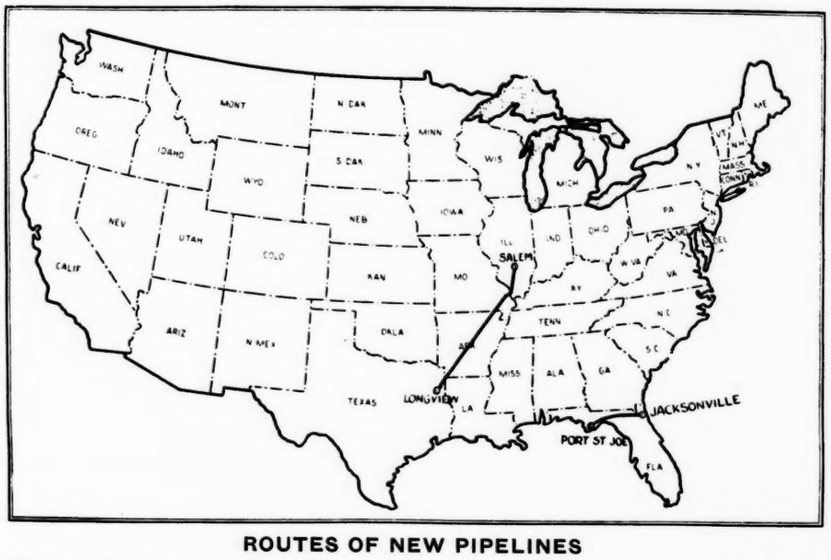
Dr. John W. Frey, director of the OPC's marketing division: Said reserve stocks of petroleum this year were "dangerously low," and that it was "extremely important" that transportation facilities be used now to build storage in the event of a severe winter.

Wiley Butler, chairman of the Atlantic Coast Oil Association Conference: Declared that he "looked with dread to Winter if we don't stop delivery of unessential gasoline to the Eastern market and bring in fuel oil instead."

Mr. Butler testified that 100,000 barrels of gasoline in excess of quota needs was moving into the East daily. An equivalent amount of heating oil, he said, would provide 2,000 homes.

Converting

It is reported that only between ½ of 1% and 2% of the Eastern Seaboard's oil burning house heating plants have been converted to coal. On the other hand, conversions have



ROUTES OF NEW PIPELINES

The 550 mile, 24 inch line from Texas to Illinois is now being built, expected to be completed by November or December. The Florida line will have a diameter of 8 in. and be 220 miles long. Its construction has been approved.

been numerous among heavy fuel oil users, and the savings from these is estimated now at 23 million barrels per year. In addition, in areas served by steam utilities there have been a fair number of conversions to street steam. New York Steam Corp. reports conversion contracts representing additional revenues of $1.4 million, 14% of a year's gross business. Only $80,000 were conversions to steam from coal, the remainder was oil to steam.

Three additional warnings (among others) urging conversion appeared from Washington in July. One was by Brig. Gen. Brice P. Disque, Assistant Director of the Office of Solid Fuels Coordinator for War, and two from Petroleum Coordinator Ickes. Mr. Ickes said:

"It seems to this Office, therefore, that the only prudent course for those who heat their homes with oil is to heed the advice of the [oil] industry: for those who can to convert now to coal.

"I commend the petroleum industry for its frank, open statement of the facts of the situation. The thing to be desired now is that the public accept the industry's statement at face value and act accordingly.

"I can say that I, personally, will follow the advice of the petroleum industry to heat my home this coming winter with coal instead of with oil, if the necessary change in my heating plant can be effected. Furthermore—and this is no secret—I know several oil company officials who are doing likewise.

"Now, why am I and why are they making this change? The reason is that they, and I, want to be certain that our families shall not suffer for lack of heat during the cold winter months ahead."

Mr. Ickes added that stocks of heating oils at the close of May were 55% below what they were a year ago, and said that there is no prospect now of our being able to build them up again to required levels. He concluded by saying that: "These facts, taken together, spell to me only one thing: that all house-holders using oil heat cannot expect to heat their homes with oil next winter."

General Disque, in his statement, said that "if the entire Northeast continues to use fuel oil as usual, then the supply as now expected will compel rationing on at most a two-thirds basis."

Governor Herbert Lehman of New York called for conversion in that state on July 30, and the Port of New York Authority asked for rationing in the Midwest. Oil industry spokesman voiced the belief that the new restrictions may be a curtain-raiser to a coupon system.

As indicated on these pages last month [See H. and V., July, 1942, p. 46] an Anthracite Industries Laboratory survey showed that 25% of oil burner owners could easily convert to coal. On the other hand, and adding to the confusion, conversion of oil burners to coal use was declared impractical following a survey conducted by Elliott-Lewis Co., Inc., Philadelphia, distributor of automatic oil heating equipment, and released July 27. The study advocates a plan involving conservation of all fuels.

J. E. Rowland, vice-president of the company, in a pamphlet summarizing findings of the survey, said that the cost of conversion is too great for most small home owners, and he contended, further, that the belief that unlimited quantities of coal are available is a fallacy.

The average cost of converting a small furnace would be approximately $50, according to Mr. Rowland. Moreover, in most cases, at the time of installation, the grate lugs were sawed off or knocked off, thus making the bottom section useless for conversion. Therefore, in addition to grates, the furnace would require ash pit door and shaker handle and a new bottom section which would cost another $50 installed, he estimated.

Mr. Rowland added that a canvass of 700 domestic fuel oil customers, whose coal-burning boilers had been converted to fuel use, disclosed that 45% said that it was impossible for them to convert, and 85% had not kept their grates and other equipment.

Referring to the belief that there is enough coal to take care of all needs, the pamphlet observed:

"A survey of six large coal companies in the Philadelphia area disclosed that they have much less coal on hand now than at the same time last year and are having increasing difficulty in maintaining adequate inventory to take care of normal requirements.

"It was their declared opinion that they could not take care of any sizable additional volume and that the likelihood of coal rationing either by government order or sheer necessity in the winter months was very probable."

Outlining its plan for the conservation of all fuels, the company suggested that representatives of all major oil companies, independent oil companies, oil burner and transportation executives meet for the purpose of deciding definitely how much of a cut in use is necessary. A similar meeting would be called in the coal industry, according to the plan. Because gas companies are a public utility they have better control of supply and demand, it was pointed out.

"When a figure is reached," the survey continued, "all local companies, both oil and coal, should be advised of the amount of curtailment, if any, and ordered to contact their users to advise them to adjust their homes and heating plants to take care of the curtailment without necessarily reducing temperature below the line of the requirement of health and reasonable comfort."

With the cooperation of the United Mine Workers, the anthracite coal industry can meet the coal demands of regular customers and 400,000 east coast converted oil furnaces, it was announced July 28 by Gordon C. Cooke, president of the Delaware, Lackawanna and Western Coal Company, sales distributor for the Glen Alden Coal Company.

Under the industry's present contract with the United Mine Workers, Mr. Cooke explained, only a twelve-week period of six days of work a week is required. The industry is negotiating with John L. Lewis, president of UMW, to lift the restriction immediately to bolster the industry's 50,000,000-ton 1941 production by 10,000,000 tons this year.

Mr. Cooke said he believed Mr. Lewis would back the change "if he can be convinced the extra production is necessary and the fuel oil confusion is clarified."

Dealers now have grates available to fit from 50 to 60 per cent of the east coast's 1,400,000 oil burners, 80 per cent of which have boilers converted to oil from coal, according to an anthracite executive in New York. The grates cost $1 per inch diameter and the average boiler or furnace requires a grate diameter of nineteen to twenty-three inches. If supporting lugs were removed at the time of oil conversion, new supports are also available for $3.50. The average non-mechanical minded home owner without grates could thus convert, hiring a plumbing or heating contractor to do the work, for $50 or less, Mr. Cooke said.

Approximately 300 grates are being manufactured a week at present, more than the present demand, but "production could quickly be stepped up to many times that number," Mr. Cooke said. No priorities are required for conversion equipment.

ASHVE to Cooperate

On July 21 the American Society of Heating and Ventilating Engineers through its War Service Committee called a meeting of interested groups directly concerned with the current fuel emergency. The meeting was held in the Hotel Pennsylvania and among those present were: Walter Fleisher, past president of the ASHVE and chairman of the committee; A. V. Hutchinson, secretary of the ASHVE; Marc Bluth, secretary of the Stoker Man-

J. W. West, Jr.

ufacturers Association; Allen J. Johnson, director of the Anthracite Industries Laboratory; R. E. Ferry, secretary of the Institute of Boiler and Radiator Manufacturers; R. A. Locke, secretary of Steel Heating Boiler Institute; Joseph C. Fitts, secretary of Heating, Piping and Air Conditioning Contractors National Association; Wharton Clay, secretary, National Mineral Wool Association; W. F. Schuyler, Air Conditioning and Refrigeration Department, General Electric Co.; R. A. Richardson, special representative, Emergency Committee of the Oil Burner Industry; John James, technical secretary of ASHVE; R. K. Thulman, chief mechanical engineer, Federal Housing Administration; John F. Collins, Jr., secretary of the National District Heating Association; and representatives and editors of business papers, newspapers, magazines and news services.

In his opening address of the luncheon which followed a closed meeting of the secretaries of the Associations named above, Mr. Fleisher said that "the situation is tremendously serious but the public does not believe it." With this in mind he said that "the ASHVE felt that, as an interested group, it should coordinate information on fuel production, fuel availability, distribution, allocation, conservation, and conversion. For that reason the meeting was called in order to decide in just what way the American Society of Heating and Ventilating Engineers could properly collect and disseminate such information."

The following summarizes some of the pertinent observations of the various speakers at the luncheon:

Allen Johnson

Johnson—The anthracite mines are now operating at the highest production rate in their history. There is no anthracite shortage. In addition the available coal cars are ample, the trackage of the anthracite coal carriers is not filled to capacity with movement of war goods and the only possibility of shortage of transportation of anthracite is that of locomotives. However, this probably will not be serious due to the proximity of the anthracite mines to the consuming areas; the center of production is only 90 miles from the center of utilization, New York City.

Ferry—Referred to the work done at the University of Illinois, which showed that the reduction of inside temperatures in an insulated house from 72 to 65F resulted in an approximate 14% fuel saving.

Walter Fleisher

Fleisher—Only 20,000 oil burner installations along the Eastern Seaboard have been converted. The main problem seems to be how we can get more converted to the use of coal. Probably only 60% of normal oil quantities will be available.

Johnson—The anthracite industry believes that oil burner users will do nothing so long as they have any oil at all, and will not convert until their tank is completely empty. This would occur sometime during the fall or winter, and at that time the tasks of getting the job converted and of supplying coal may be serious.

Wharton Clay

Clay—The capacity of the mineral wool industry, and its distributors, along the Eastern Seaboard is the insulation of ceilings and walls of approximately 600,000 houses by January 1, at an average cost of $225 per house. Such insulation, he said, would result in a sharp drop in fuel consumption.

Thulman—The public is in the confused situation of not knowing whether they should convert, insulate, or adopt other conversion methods. There is a need for some unit or formula to indicate to a home owner what can be accomplished in his specific house by various conversion methods.

J. C. Fitts

Fitts—The element of time is involved. In any conversion job it is necessary for journeymen to inspect the installation, take the tools to the job, and then spend actual time on the labor of it. In addition the steam fitters are hampered by gas and tire shortages. Nevertheless, the contractors of the country are equipped to handle the necessary conversion work provided that such conversions are begun in August or not later than September, before the heating season really begins.

Schuyler—Referred to the Anthracite Industries survey which showed that 25% of oil burner users have their grates and pointed out that these were the logical people who should convert first and that a campaign should be directed toward this end. Then, following this, pressure should be directed on remaining oil users to conserve their fuel by use of insulation or other conservation measures.

J. F. Collins, Jr.

Considerable newspaper publicity resulted from the meeting. It had previously been decided that perhaps the most direct method of bringing the seriousness of the situation to home owners would be to request President Roosevelt to make this the subject of a fireside chat. This request is to be made.

Hot Water Conservation

The 50% restriction on consumption of fuel oil is being met by some New York apartment houses by limiting the supply of hot water during part of the morning and afternoon, according to New York real-estate men. WPB reports that the same policy will be followed by other apartment house landlords in the seventeen Atlantic seaboard states affected.

One real-estate office said some apartment houses are cutting off hot water between 11 a.m. and 4 p.m.

The Brooklyn Real Estate Board said Brooklyn landlords also are limiting the use of hot water. "Tenants are co-operating and it is hoped the present condition is temporary and that ways will be found to bring in larger supplies of fuel oil in the near future," the board said.

Another real-estate office, which manages about 100 houses in Greenwich Village, said landlords are converting their burners from oil to coal. He said the government is expected to issue priorities to make conversion possible before winter. He estimated that about 25% of the apartment houses in New York burn oil.

Northwest Oil Eased

Removal of restrictions on fuel oil deliveries in Oregon and Washington was recommended by the Office of Petroleum Coordinator, and issued by WPB as an amendment to Limitation Order L-56, thus lifting the 50% curtailment on fuel oil deliveries which became effective in that area May 16.

Deputy Coordinator Ralph K. Davies, however, strongly urges home owners in those states to operate fuel-oil burning equipment as though the 50% restriction were

(Concluded on page 52)

MOTORS
THEIR SELECTION & MAINTENANCE

HEATING AND VENTILATING'S REFERENCE SECTION

6

ELECTRIC MOTORS—THEIR SELECTION AND INSTALLATION

By O. F. VEA

Motor Division, General Electric Co.

As the materials situation grows more and more acute, due to the ever-increasing demands of war, the need for keeping all kinds of existing plant equipment in the best possible operating condition becomes of paramount importance. No longer is maintenance work a question of making prompt repairs and replacement of parts when troubles occur, since under present conditions a total lack of parts sometimes can make such repairs impossible; rather, it has become a question of anticipating and preventing all such equipment failures if at all possible. This can be accomplished chiefly through intensified programs of inspection and systematic care of important equipment. Electric motors are one of the basic equipments of industry. In the accompanying article, the author outlines a comprehensive program of selection, installation, and care for all the ordinary types of motors. While mainly directed toward industries of medium or large size, which have their own maintenance organizations, most of the material is equally suitable for the very small commercial establishment, or in fact for anyone who has a motor which must be kept operating and who needs a few simple important facts pointed out to him as to how best to take care of the motor.

Present-day conditions make it necessary that all electric motors be babied. Maintenance programs must be intensified to prevent breakdowns, because 24-hour-a-day, 7-day-a-week war production schedules must not be interrupted. In nondefense work, too, the motor maintenance problem is fast becoming vital because of the difficulty in obtaining new motors or parts, due to priority requirements.

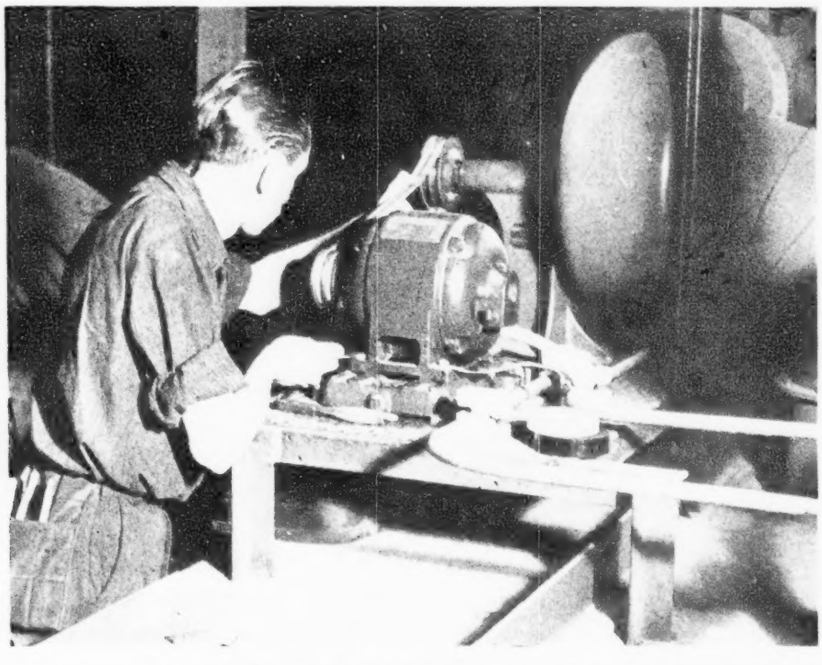
This article will discuss a general maintenance program. Wherever available the specific instruction sheet accompanying each motor should be followed.

A real maintenance program begins with selection. Motors must be chosen that are properly rated and protected for their work. The selection involves a study of requirements, such as continuous or intermittent duty, starting torque, speed regulation, and the like. Environment, too, must be considered. These all have a bearing on just what type of motor to choose.

Tables 1 and 2 show characteristics and applications of standard a.c. and d.c. motors, respectively.

Installation is fully as important as selection. The motor should be located in such a way that it is accessible for inspection and repairs, and in a place free from adverse conditions unless it is built in a protecting enclosure. There should be ample ventilation so that motor heat losses will be carried away.

A standard motor should not be installed where the ambient temperature or normal temperature rise is more than 40C. The motor should rest on a solid foundation free from vibration. If direct-connected or belted, care should be taken to secure proper alignment, which should permit rotor end-play within reasonable limits.



Install the motor in such a way that it is accessible for inspection and repairs. Care should be taken to align the motor properly with the driven load.

SELECTION AND MAINTENANCE

Connecting the Motor

All connections should be tight so that vibration will not loosen them. Wires joined in a conduit box should be either twisted together and soldered, or bolted together. These joints should be wrapped first with rubber tape, and then with friction tape. Wires issuing from a conduit box should be held in some way, preferably by suitable conduit box fittings so that there is no strain on the connections themselves.

Starting the Motor

A little extra care when starting a motor for the first time is a good investment. For example, trouble may be avoided by a look at the brushes of a direct-current or single-phase repulsion motor to make sure that they are seating properly on the commutator, and with the proper pressure. It is always good practice to turn the motor over by hand before applying power to be sure that it turns freely.

INSPECTION SCHEDULES

To insure efficient operation and maximum production, inspection and servicing should be systematic. Frequency and thoroughness will have to be determined by the maintenance engineer, but should be governed by (1) the importance of the motors in the production scheme, (2) percentage of time the motor operates, (3) nature of service, (4) environment.

An inspection schedule must, therefore, be elastic and adapted to the needs of each plant. The following, covering both a-c and d-c motors, is based on average conditions in so far as duty and dirt are concerned:

Every Week

1. Examine commutator and brushes
2. Check oil level in bearings
3. See that oil rings turn with shaft
4. See that shaft is free of oil and grease from bearings
5. Examine starter, switch, fuses, and other controls
6. Start motor and see that it is brought up to speed in normal time.

Every Six Months

1. Clean motor thoroughly, blowing out dirt from windings and wipe commutator and brushes
2. Inspect commutator clamping ring
3. Check brushes and renew any that are more than half worn
4. Examine brush holders and clean them if dirty. Make sure that brushes ride free in the holders
5. Check brush pressure
6. Check brush position
7. Drain, wash out, and renew oil in sleeve bearings
8. Check grease in ball or roller bearings
9. Check operating speed or speeds
10. See that end play of shaft is normal
11. Inspect and tighten connections on motor and control
12. Check current input and compare with normal
13. Run motor and examine drive critically for smooth running, absence of vibration, worn gears, chains, or belts
14. Check motor foot bolts, end-shield bolts, pulley, coupling, gear and journal set-screws, and keys
15. See that all motor covers, belt and gear guards are in good order, in place, and securely fastened.

Once a Year

1. Clean out and renew grease in ball or roller bearing housings
2. Test insulation by megger
3. Check air gap
4. Clean out magnetic dirt that may be hanging on poles
5. Check clearance between shaft and journal boxes of sleeve-bearing motors, to prevent operation with worn bearings
6. Clean out undercut slots in commutator
7. Examine connections of commutator and armature coils
8. Inspect armature bands.

Records

The competent maintenance man will have a record card for every motor in the plant. All repair work, with its cost, and every inspection can be entered on the record. In this way, excessive amounts of attention or expense will show up and the causes can be determined and corrected.

LUBRICATION

One of the major features of a maintenance program, from the standpoint of effect upon the general performance of a motor, is proper lubrication. Although the bearings of modern motors, whether sleeve, ball or roller, require only very infrequent attention, ultimate failure often is hastened by improper lubrication, due to the entrusting of this operation to careless attendants.

Greasing Ball-bearing Motors

Only a high grade of grease, having the following general characteristics, should be used for ball-bearing lubrication:

1. Consistency a little stiffer than that of vaseline, maintained over the operating-temperature range
2. Melting point preferably over 150C
3. Freedom from separation of oil and soap under operating and storage conditions
4. Freedom from abrasive matter, acid, and alkali.

In greasing a motor, care must be taken not to add too large a quantity of grease or it will cause too high an operating temperature with resulting expansion and leaking of the grease, especially with large bearings operated at slow speeds.

The following procedure is recommended for greasing ball-bearing motors equipped with a pressure-relief greasing system:

Make sure that no dirt gets into the bearing with the grease by wiping clean the pressure-gun fitting, bearing housing, and relief plug. Always remove the relief plug from the bottom of the bearing and remove any hardened grease from the hole before using the grease gun. This prevents putting excessive pressure inside the bearing housing. Excessive pressure might rupture the bearing seals.

With the motor running, add grease with a hand-operated pressure gun, until it begins to flow from the relief hole. This tends to purge the housing of old grease. If too

dangerous to lubricate the motor while it is running, follow the procedure with the motor stopped.

Allow the motor to run long enough after adding grease to permit the rotating parts of the bearing to expel all excess grease from the housing. This very important step prevents over-greasing the bearing. Finally, stop the motor and replace the relief plug tightly with a wrench.

A motor that is not equipped with the pressure-gun fitting and relief plug on the bearing housing cannot be greased by the above procedures.

Under average operating conditions, the grease with which the bearing housings of these motors were packed before leaving the factory is sufficient to last approximately one year. When the first year of service has elapsed, and once a year thereafter (or oftener if conditions warrant) the old grease should be removed and the bearings supplied with new grease.

To do this, disassemble the bearing housings and clean the inside of the housings, the housing caps, and the bearings, with carbon tetrachloride. When thoroughly cleansed of old grease, reassemble all parts except the outer caps, or plates.

Apply new grease, either by hand or from a tube, over and between the balls. Addition of the correct amount of grease fills the bearing housings one-third to one-half full. More than the amount specified on the manufacturer's instruction sheet must not be used. When reassembling the motor, any V-grooves that are found in the housing lip should be refilled with grease—preferably a fibrous, high-temperature-sealing grease which will act as an additional protective seal against the entrance of dirt or foreign particles.

Greasing Roller Bearings

The technique for greasing motors equipped with roller bearings is very similar to that used for ball bearings.

Specific instructions for the individual design should be followed, however, because more frequent greasing or slight changes in technique may sometimes be necessary.

Oiling Sleeve Bearings

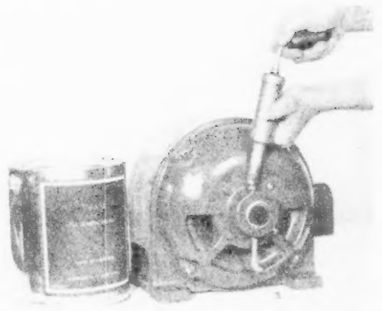
The oil level in sleeve-bearing housings should be checked periodically with the motor stopped. If the motor is equipped with an oil-filler gage, the gage should be approximately three-quarters full at all times.

If the oil is dirty, drain it off by removing the drain plug, which is usually located in the bottom or side of the bearing housing. Then flush the bearing with clean oil until the outcoming oil is clean.

In fractional-horsepower motors, there may be no means of checking oil level, as all the oil may be held in the waste packing. In such cases, a good general rule for normal motor service is to add thirty to seventy drops of oil at the end of the first year and to re-oil at the end of each subsequent one-thousand hours of motor operation.

Most fractional-horsepower motors built today require lubrication about once a year. Small fan and agitator motors will often require more frequent lubrication, with three-month intervals between oilings.

Sleeve bearing housings are provided with liberal settling chambers into which dust, dirt, and oil sludge collect. The only cleaning necessary is to remove the drain plug and drain the oil, which will flush out most of the settled material with it.



For convenience of a maintenance man, many motors have ball bearings arranged to be greased with a pressure gun. Here is a standard ball-bearing open motor being greased after hardened grease has been removed. Pressure-relief greasing system facilitates adding correct amount of grease.

Whenever the motor is disassembled for general cleaning, the bearing housing should be washed out with a solvent. Before being assembled, the bearing lining should be dried and the shaft covered with a film of oil.

Cleaning Ball Bearings

The pressure-relief method of greasing motors, described above, tends to purge the bearing housing of used grease. Complete cleaning of bearings, therefore, is required at infrequent intervals only. For a thorough and convenient flushing when the bearings are not disassembled, the following method is recommended:

After wiping off external dirt and grease, remove the pressure-gun and relief fittings, then remove any hardened grease from the holes, taking care that no dirt or grit gets into the bearing.

Fill a syringe with grease solvent,

Connections to a motor should be made tightly enough so that the vibration of the equipment will not loosen them. Wires joined in a conduit box should be either twisted together and soldered, or bolted together. These joints should be wrapped first with rubber tape, and then with friction tape.

such as carbon tetrachloride, and inject some of it into the bearing housing through the pressure-fitting hole, while the motor is running. As the grease becomes thinned by the solvent, it will drain out through the relief hole. Continue to add solvent until it drains out clear.

Replace the relief plug and inject solvent until it can be seen splashing in the filling hole. Allow the solvent to churn for a few minutes, and then remove the relief plug and drain off the solvent. Repeat the churning operation until the solvent runs clean.

When using carbon tetrachloride for flushing, replace the relief plug and inject a small amount of light lubricating oil. Allow it to churn for a minute or two before draining off. This will flush out the solvent. To complete the job, grease the bearing, using the method previously described.

This method permits the cleaning of all standard motors operating at an angle not exceeding 15 degrees from the horizontal (except totally enclosed, fan-cooled motors). For these motors, the bearing at the pulley end may be flushed as described. To clean the fan-end bearing, first remove the fan cover and fan in order to make accessible the drain plug at the bottom of the housing.

CARE OF INSULATION

Care of insulation goes hand in hand with lubrication as one of the major features of a motor maintenance program. These features concern the most vital, and probably the most vulnerable, parts of an electric motor.

Motors should always be stored in a dry, clean place until ready for installation. Heat should be supplied to protect against alternate freezing and thawing.

Motors that have been long in transit in a moist atmosphere, or idle for an extended period, should be thoroughly dried out before being placed in service. Since machines sometimes "sweat" as a result of a difference in their temperature and that of the surrounding air, they should be kept warm at all times to prevent this condition.

Current at a low voltage can be passed through the windings, electric heaters can be used, or even steam pipes can be utilized for protective purposes. In the case of extended idle periods, tarpaulins may be stretched over the motor and a small heater put inside to maintain the proper temperature.

Drying Out

The most effective method of drying out motors that have become wet by accident or because of sweating is to pass current through the windings, using a voltage low enough to be safe for the winding in its moist condition.

Thermometers should be placed on the windings to see that they are heated uniformly. Temperatures should not exceed 90C (Class A insulation). This method is particularly effective on high-voltage motors, where the insulation is comparatively thick.

Motors also can be dried by covering with canvas and circulating fresh warm air through them, the air temperature not to exceed 100C. Smaller machines can be over-dried, this same temperature limit being observed.

Insulation Resistance Tests

The time required for complete drying-out depends considerably on the size and voltage of the motor. Insulation resistance measurements should be taken at intervals of four or five hours until a fairly constant value is reached. These tests are a good indication of the general condition of the insulation and its ability to stand the operating voltage.

The resistance should at least equal the recommended AIEE standard, which is:

$$\text{Megohms} = \frac{\text{Rated voltage of the machine}}{\frac{\text{Rating in kva}}{100} + 1000}$$

Insulation resistance tests should also be made before a high-potential test, to determine whether the insulation is ready for such a test, and afterwards to make certain that the high-potential has not injured the insulation.

High-potential Tests

High potential tests should be made after drying out or after repairs to check the dielectric strength of the insulation.

New windings should successfully stand a high-potential test of twice normal voltage plus 1000. Motors that have been in operation for some

Check motor foot bolts and end-shield every six months to make sure that they are securely fastened. Where an adjustable base and V-belt drive is used see that all four motor base bolts are kept tight, and that belt is kept snug.

time should be tested with this method, after thorough cleaning and drying, using a voltage of about 150%, of normal, applied for one minute.

Small high-potential testing sets are available for such work and are of such capacity that very little damage will result from a breakdown during the test.

CLEANING AND OVERHAULING

A systematic and periodic cleaning of motors is necessary to insure best operation. Dust offers one of the worst problems in motor maintenance. Many dusts are highly abrasive and actually cut the insulation in being carried through by the ventilating air.

If conditions are severe, open motors might require a certain amount of cleaning each day. For less severe conditions, weekly inspection and partial cleaning are desirable.

For the weekly cleaning, the motor should be blown out with dry, compressed air (about 25 to 30 lb per sq in. pressure). Where conducting and abrasive dusts are present, even lower pressure may be necessary, and suction is to be preferred, as damage can easily be caused by blowing the dust and metal chips into the insulation. On larger d.c. machines, the air ducts should be blown out so that the ventilating air can pass through as intended.

In cleaning a motor, the heavy dirt and grease should first be removed with a heavy, stiff brush, wooden or fiber scrapers, and cloths. Rifle-cleaning brushes can be used in the air ducts. Dry dust and dirt may be blown off, using dry compressed air at moderate pressure.

Grease, oil, and sticky dirt are easily removed by applying cleaning liquids like carbon tetrachloride, gasoline, or naphtha. There are

TABLE 1.—CHARACTERISTICS AND APPLICATIONS OF SINGLE-PHASE MOTORS†

Type of Motor	Speed	Full Load Power Factor	Starting Current	Torques: Starting	Torques: Pull-up	Applications*
Repulsion[1,5]	Varying-series characteristic	High	Low	Very High	—	Special applications for which motor is specifically designed, for example, threading machines.
Repulsion-Start Induction-Run[2,5]	Constant	Medium	Low	Very High	Medium	Where high starting torque is required. Refrigeration compressors, piston type pumps, some belted fans and blowers, stokers, large oil burners.
Repulsion-Induction[2,5]	Constant	Very high	Low	High	High[11]	Same as for repulsion-start, induction-run.
Capacitor Permanent-Split[3,4,5]	Constant or adjustable varying	Very high	Medium	Very Low	Medium[11]	Direct connected fans and other loads requiring low starting torque.
Capacitor-Start Capacitor-Run[3,6,9]	Constant	Very high	Low	High	High	Same as repulsion-start, induction-run when torque is high. When medium it is used on some belted fans and blowers, centrifugal compressors and pumps, and large oil burners.
Capacitor-Start Induction-Run[3,6,9]	Constant	High	Medium	High	High	Same as repulsion-start, induction-run.
Split-Phase General Purpose[4,7,9]	Constant	High	Medium	Medium	Medium	Fractional hp sizes only. Used on oil burners, direct connected and belted fans, unit heaters, blowers, centrifugal pumps, miscellaneous, medium torque applications.
Special Purpose[4,7,8]	Constant	Medium	High	Quite High	Medium	Fractional hp sizes only; intended for applications used infrequently but often on applications such as shown under general purpose, split phase. Also on small machine tools, washing machines and other applications where high starting current and medium efficiency are not objectionable.

*This general comparison of single-phase motors should be used only as an application guide. Performance characteristics are interrelated, may vary considerably, and depend upon individual design considerations for specific ratings. †Type of rotor: wound armature with commutator. ‡Type of rotor: wound armature imbedded squirrel-cage and commutator. §Type of rotor: squirrel-cage. ¶Transfer mechanism: none. **Transfer mechanism: short circuiting devices and sometimes a brush-lifting mechanism. ††Transfer mechanism: switch or voltage relay. ‡‡Transfer mechanism: centrifugal switch. §§Full load efficiency: medium. ¶¶Full load efficiency: high. ***Full load efficiency: very high. †††Transition from starting to running condition accomplished electrically. The pull-up torque is the same as the maximum torque.

several good methods of applying the liquid, spraying probably being the best. Dipping is apt to soak the insulation, and should be avoided.

While the insulation will dry quickly at ordinary room temperature after cleaning, it is highly desirable to heat it at 90 to 100C to drive off all moisture before applying varnish.

While the motor is warm, a high-grade insulating varnish should be applied. For severe acid, alkali, or moisture conditions where oil or dusts are present, special varnishes can be supplied.

The varnish may be sprayed or brushed on. For small stators or rotors, it is best to dip the windings into the varnish, cleaning off the adjacent metal parts afterwards by using a solvent of the varnish. After applying the varnish, the best results are obtained by baking for a length of time recommended by the varnish manufacturer, which often is from 3 to 7 hours at about 100C.

If the machine must be put back in service quickly, or if facilities are not available for baking, fairly good results will be obtained by applying one of the quick-drying black or clear varnishes which dry in a few hours at ordinary room temperatures.

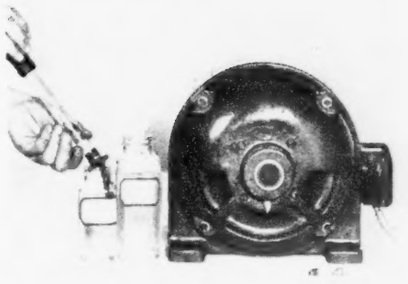
Motors normally should be given a general overhauling at intervals of about five years, or oftener, if the service is severe. Where this periodic overhauling is practiced, the following notes may be helpful.

General Overhauling

Check the motor air gap, between stator and rotor, with feelers for uniformity. Small clearance at the bottom may indicate worn bearings.

Take the motor apart and inspect it thoroughly. Measurement of the bearings and journals may indicate need for new bearing linings. Remove the waste from waste-packed bearings and rearrange or replace it, so that any glaze on the wool is removed from its point of contact with the shaft. Any gummy deposit means that the wool should be replaced. All lubricant should be cleaned out of the bearings and a fresh supply put in when the motor is reassembled.

The rotors should be cleaned with a solvent to remove any accumulated dirt, after which any rust should be removed with fine sandpaper (not emery paper). When clean and dry, the rotors should be coated with a good grade of clear varnish or lacquer to protect them from moisture. To prevent injury to the bearings, they should be completely protected with a clean rag when the motor is disassembled.



Thorough cleaning of ball-bearing housings at periodic intervals is beneficial in obtaining long bearing life. Housing of this motor can be flushed without disassembling motor.

The rotors of wound-rotor motors should be given the same treatment as the stators. In addition, soldered joints and binding cords should be inspected and any weakness remedied.

The stator bore should be cleaned of dirt with a solvent, and any rust should be removed with fine sandpaper (not emery paper). Care should be taken during this opera-

TABLE 2. CHARACTERISTICS AND APPLICATIONS OF POLYPHASE AC MOTORS

Type of Motor	Ratings, Hp	Speed Regulation	Speed Control	Starting Torque	Pull-Out Torque	Typical Applications
General-purpose squirrel-cage	0.5 to 200	Drops about 5% for large to 5% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	200% of full-load for 2-pole to 105% for 10-pole designs	200% of full-load	Constant speed service where starting torque is not excessive. Direct-connected and belt-connected fans and blowers, centrifugal and piston pumps, refrigeration compressors, stokers, machine tools, line shafts, wood-working machines.
Full-voltage starting, high starting torque, low starting current, squirrel cage	3 to 150	Drops about 3% for large to 6% for small sizes	None, except multi-speed types, designed for 2 to 4 fixed speeds	250% of full-load for high-speed to 200% for low-speed designs	200% of full-load	Constant-speed service where fairly high starting torque is required at infrequent intervals with starting current of about 400% full load. Reciprocating pumps and compressors, conveyors, crushers, agitators.
Full-voltage starting, high-starting torque, high-slip, squirrel cage	0.5 to 150	Drops about 7 to 12% from no load to full load	None, except multi-speed types, designed for 2 to 4 fixed speeds	300 to 315% of full load, depending upon speed and rotor resistance	300%. This motor will usually not stall until loaded to its maximum torque, which occurs at standstill	Constant-speed service and high starting torque if starting not too frequent, and for taking high-peak loads with or without flywheels. Elevators, punch presses, die stamping, shears, bulldozers, bailers, hoists, cranes.
Wound-rotor external-resistance starting	0.5 to several thousand	With rotor rings short-circuited, drops about 3% for large to 5% for small sizes	Speed can be reduced to 50% of normal by rotor resistance. Speed varies inversely as the load	Up to 300% depending upon external resistance in rotor circuit and how distributed	200% when rotor slip rings are short-circuited	Where high starting torque with low-starting current or where limited speed control is required. Fans, centrifugal and plunger pumps, compressors, conveyors, hoists, cranes, ball mills, gate hoists.
Synchronous	25 to several thousand	Constant	None, except special motors designed for 2 fixed speeds	40% for slow-speed to 160% for medium speed 80% pf designs. Special high-torque designs	Unity-pf motors 170%; 80% = pf motors 225%. Special designs up to 300%	For constant speed service, and where power factor correction is required. Large centrifugal pumps, belt-connected reciprocating compressors, fans, blowers, line shafts, various mills, and d-c generators.

TABLE 3. CHARACTERISTICS* AND APPLICATIONS OF DC MOTORS, 1 TO 300 HP

TYPE	STARTING DUTY	MAXIMUM MOMENTARY RUNNING TORQUE	SPEED REGULATION	SPEED CONTROL†	APPLICATIONS
Shunt-wound, constant-speed	Medium starting torque. Varies with voltage supplied to armature; usually limited by starting resistor to 125 to 150 per cent full-load torque	125 to 150 per cent. Limited by commutation	5 to 15 per cent	Basic speed to 150 per cent basic speed by field control	Drives where starting requirements are not severe. Use constant-speed or adjustable-speed, depending on speed required. Centrifugal pumps, fans, blowers, stokers, conveyors, elevators, wood- and metal-working machines, refrigeration compressors, oil burners.
Shunt-wound, adjustable-speed			25 to 50 per cent increase with weak field	Basic speed to 1000 per cent basic speed (lower for some ratings) by field control	
Compound-wound, constant-speed	Heavy starting torque. Limited by starting resistor to 175 to 250 per cent or full-load torque	225 to 350 per cent. Limited by commutation	Standard compounding 15 per cent. Depends on amount of series winding	Basic speed to 125 per cent basic speed by field control	Drives requiring high starting torque and fairly constant speed. Pulsating loads. Shears, bending rolls, plunger pumps, conveyor crushers, etc.
Series-wound, varying-speed	Very heavy starting torque. Limited to 200 per cent to 225 per cent full-load torque	350 to 450 per cent. Limited by commutation	Very high. Infinite no-load speed	From zero to maximum speed, depending on control and load	Drives where very high starting torque is required and speed can be regulated. Cranes, hoists, gates, bridges, car dumpers, etc.

*Table shows average values for standard motors.
†Minimum speed below basic speed by armature control limited by heating.

tion not to damage the top sticks or end turns of the stator winding. When the stator bore has dried, any remaining dirt in the bore should be wiped out with a cloth or brushed out with a soft brush. A hand bellows or dry compressed air at low pressure may also be used.

DIRECT CURRENT MOTORS

To insure efficient operation of d-c motors, the following additional inspection and servicing should be done:

Brush Inspection

The first essential for satisfactory operation of brushes is free movement of the brushes in their holders. Uniform brush pressure is necessary to assure equal current distribution. Adjustment of brush holders should be set so that the face of the holder is approximately 1/8 in. up from the commutator; any distance greater than this will cause brushes to wedge, resulting in chattering and excessive sparking.

Check the brushes to make sure that they will not wear down too far before the next inspection. Keep an extra set of brushes available, so that replacement can be made when needed. Sand in new brushes, and run the motor without load as long as possible.

Make sure that each brush surface in contact with the commutator has the polished finish that indicates good contact, and that the polish covers all of this surface of the brush. Check the freedom of motion of each brush in the brush holder.

When replacing a brush, be sure to put it back in the same brush holder and in its original position.

When installing new brushes, fit them carefully to the commutator. To do this, insert a strip of fine sandpaper, sand side up, between the commutator and the brush. Rotate the commutator back and forth, allowing the brushes to bear on the sandpaper only when the commutator is moving in the proper direction of rotation.

The brush should be lifted so it will not touch the sandpaper, on the back pull. Sand only until the curve of the brushes is the same as that of the commutator. Be sure that brush shunts (pigtails) are fastened securely so that current will not overheat the brushes and brush holders.

Check the springs that hold the brushes against the commutator. Improper spring pressure may lead to commutator wear and excessive sparking. Excessive heating may have annealed the springs, in which case they should be replaced and the cause of heating corrected. Larger motors have means for adjusting the spring pressure, which should be 2 to 2½ lb per sq in. of area of brush contact with the commutator.

Commutator

Inspect the commutator for color and condition. It should be clean, smooth, and a polished-brown color where the brushes ride on it. A bluish color indicates overheating of the commutator.

Roughness of the commutator should be removed by sandpapering or stoning. Never use emery cloth or an emery stone. For this operation, run the motor without load. If sandpaper is used, wrap it partly around a wood block.

The stone is essentially a piece of grindstone, known to the trade as a commutator stone. Press the stone or sandpaper against the commutator with moderate pressure with the motor running without load, and move it back and forth across the commutator surface.

Use care not to come in contact with live parts. If the armature is very rough it should be taken out and the commutator turned down in a lathe. When this is done, it is usually necessary to cut back the insulation between the commutator bars slightly. After turning down the commutator, the brushes should be sanded and run in as described previously. This is not necessary after light sandpapering or stoning.

Never put oil on the commutator. Proper selection of brushes gives the commutator all the lubrication required to prevent excessive wear and to build up a good smooth operating glazed surface on the copper. The addition of oil results in the development of a high resistance film which may cause undue heating and rough brush action. The oil will also have a detrimental effect on the internal parts of the commutator.

PIPING

Pressure Drop Calculations for Flow in Pipes

By JAMES A. HARDY and EMORY N. KEMLER

Instructor, School of Mechanical Engineering, and Professor of Mechanical Engineering, Purdue University, respectively.

In the accompanying article Professor Kemler has developed a new variation in the method of handling velocity numbers in connection with the design of piping. In addition, he introduces an entirely new and simplified method of calculating pressure drop in the flow of gas and vapors. Knowing the viscosity and density of a given fluid, the user of this article is prepared to calculate the pressure drop of liquids or gases.

DUCTS and piping when properly designed are a very economical and convenient means of transporting fluids of all types. The problems of piping design are normally divided into those involving the handling of liquids and those of handling compressible fluids.

The calculation of pressure drop in the case of the flow of liquids in uniform conduits can, in general, be satisfactorily calculated using the Darcy or Fanning formula. The only question arising in the use of this equation is that of determining the friction factor to be used. On the other hand, the problem of calculating the flow of gases or vapors is more complicated since the velocity and density will vary with the pressure and therefore will vary along the length of a uniform conduit. Consequently, the formulas commonly used in gas or vapor flow problems become much more involved and do not give a direct solution for the pressure drop. However, in both of these types of flow, the friction factor can be calculated by using the Reynolds number. In case the rate of flow corresponding to a desired pressure drop is to be determined, a direct solution using Reynolds number cannot be obtained. By introducing another dimensionless quantity, which is called the velocity number, this solution can be readily made. The following discussions will take up the evaluation of the friction factor, a simplified method of solving compressible flow problems, the use of the velocity number, and the application of these tools to the solution of problems involving the flow of liquids, steam and gases in pipes.

Friction Factor

The equation commonly used for calculating pressure drop in pipes, expressed in practical units, is

$$p_1 - p_2 = \frac{.00129\, f l \rho u^2}{d} = 43.75\, \frac{f l \rho V^2}{d^5} \qquad (1)$$

where

p_1 = inlet pressure in lb per sq in.;
p_2 = outlet pressure in lb per sq in.;
f = friction factor;
l = length of pipe in feet;
u = mean velocity of flow in ft per sec;
ρ = density in lb per cu ft;
V = volume rate of flow in cu ft per sec; and
d = pipe diameter in inches.

The only problem arising in the use of this equation is that of selecting the friction factor. Many empirical relations have been proposed for this friction factor. Such relations, if based on experimental data, will be satisfactory. If, however, the range of conditions is extended beyond the range of the data on which it is based, the empirical formulas will not necessarily apply and may result in serious error. The Reynolds number method for determining the friction factor eliminates this difficulty and makes it possible to use the friction factor determined using one fluid on problems involving some other fluid. Reynolds in his study of the flow problem found that the change of flow from viscous or laminary flow to turbulent flow depended on the dimensionless product $Du\rho/\mu$ which is called the Reynolds number and given the symbol N_R.

$$N_R = \frac{Du\rho}{\mu} \qquad (2)$$

where D = diameter in feet, and
μ = viscosity in lb per ft-sec.

Expressed in practical units (see previous symbols)

$$N_R = \frac{Du\rho}{\mu} = \frac{DW}{A\mu} = .0833\, \frac{du\rho}{\mu} = 15.3\, \frac{V\rho}{d\mu} = 15.3\, \frac{W}{d\mu}. \qquad (3)$$

where A = area in sq ft.

Regardless of the type of fluid flowing, the friction factor will be the same at the same value of Reynolds number for a given size of pipe. The friction factor cannot be calculated mathematically for any other condition than for the viscous or laminar type flow where $f = 64/N_R$ for circular pipes. For turbulent flow, which we will consider here, the friction factor must be determined from experimental data. Such a summary of the data available in the literature is given in an article on "The Flow of Fluids in Pipes" by Emory Kemler in the August, 1933, *A.S.M.E. Transactions*. R. J. S. Pigott in an article on "The

TABLE 1. SELECTED LOCATION OF f BY ROUGHNESS RELATIONS

Pipe Material*	Curve Number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Roughness, Per Cent																	
	0.2	0.45	0.81	1.35	2.1	3.0	3.8	4.8	6.0	7.2	10.5	14.5	19.0	24.0	28.0	31.5	34.0	37.5
	Pipe Diameters to Which Curves Apply, Inches																	
A	0.35 up	..	..	..	..	..	..	..	..	..	..	..	..	0.125	..	..	..	0.0625
B	72	48-66	14-42	6-12	4-5	2-3	1-½	1-1-¼	¾	½	⅜	¼	⅛	..	..	..	..	..
C	..	..	30	10-24	6-8	3-5	2-½	1-½-2	1-¼	1	¾	½	..	⅜	..	¼	..	⅛
D	..	..	48-60	20-48	12-16	5-10	3-4	2-2-½	1-½	1-¼	1	..	..	..	..	..	..	..
E	..	..	96	42-96	24-36	10-20	6-8	4-5	3	..	..	..	..	..	..	..	..	..
F	..	..	220	84-204	48-72	20-40	16-18	10-14	8	5	4	3	..	..	..	..	..	..

*A = Drawn tubing, brass, tin, lead, glass; B = Clean steel, wrought iron; C = Clean, galvanized; D = Best cast iron, cement, light riveted sheet ducts; E = Average cast iron, rough-formed concrete; F = First-class brick, heavy riveted, spiral riveted. In drawn tubing, actual inside diameter is given. In pipe, nominal size of standard weight is given.

Flow of Fluids in Closed Conduits" in the August, 1933, *Mechanical Engineering* extended these data to cover a wide range of pipe on the basis of relative pipe roughness. These data are shown in Figs. 1 and 2. Table 1 shows the types and sizes of pipes to which the various curves apply.

Liquid Flow

The application of these curves to the flow of fluids requires that the viscosity be known. Figures 3a and 3b give the viscosity of various liquids commonly encountered. (The data are from a paper by R. L. Daugherty on "Some Physical Properties of Water and Other Fluids," A.S.M.E. Summer Meeting, 1934.) Fig. 4 gives data on the viscosity of gases and Fig. 5 the viscosity of steam (as given by Leib in the December, 1940, issue of *Combustion*).

Example 1:

Determine the pressure drop for 1000 ft of 2 inch wrought iron pipe handling 30 gpm of water at 60 F.

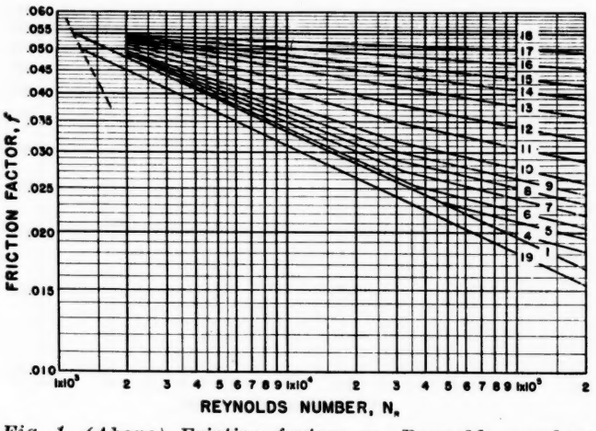


Fig. 1. (Above) Friction factors vs. Reynolds numbers for values of N_R from 1000 to 100,000.

Fig. 2. (Right) Friction factors vs. Reynolds numbers for values of N_R from 100,000 to 10,000,000.

Solution:

$$V = \frac{30 \text{ gpm}}{7.48 \text{ gal per cu ft} \times 60 \text{ sec per min}} =$$

0.0668 cu ft per sec;

$\mu = 2.4 \times 10^{-5}$ lb per ft-sec from Fig. 3 at 60 F;
$\rho = 62.4$ lb per cu ft; and
d = 2.067 in (actual internal diameter).

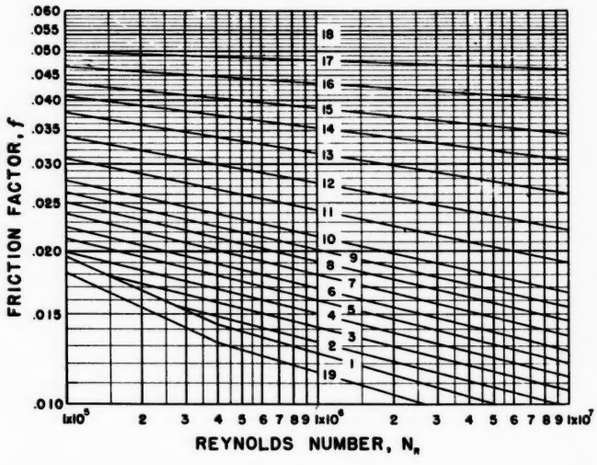
From equation (3)

$$N_R = 15.3 \frac{V\rho}{d\mu} = 15.3 \frac{.0668 \times 62.4}{2.067 \times 2.4 \times 10^{-5}} = 1.29 \times 10^6$$

From Fig. 1, f = .0163

From equation (1)

$$p_1 - p_2 = 43.75 \frac{fl\rho V^2}{d^5} = 43.75 \frac{.0163 \times 1000 \times 62.4(.0668)^2}{2.067^5} = 5.26 \text{ lb per sq in.}$$



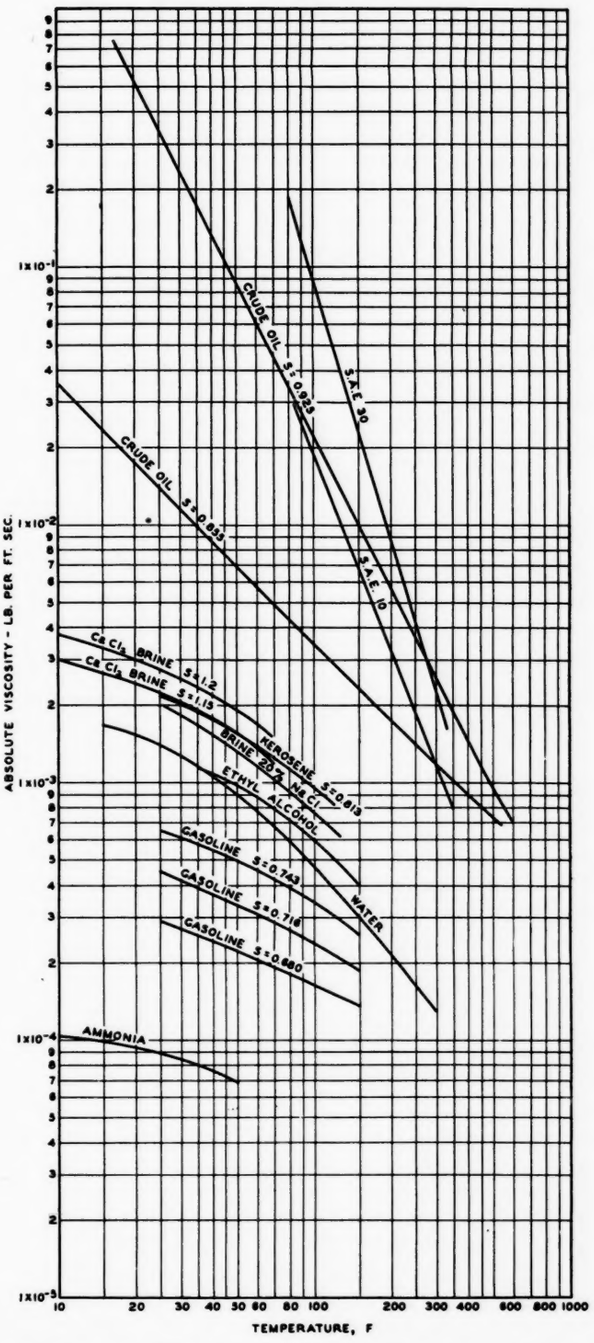


Fig. 3a. Absolute viscosity of various fluids at different temperatures. (From Daugherty.)

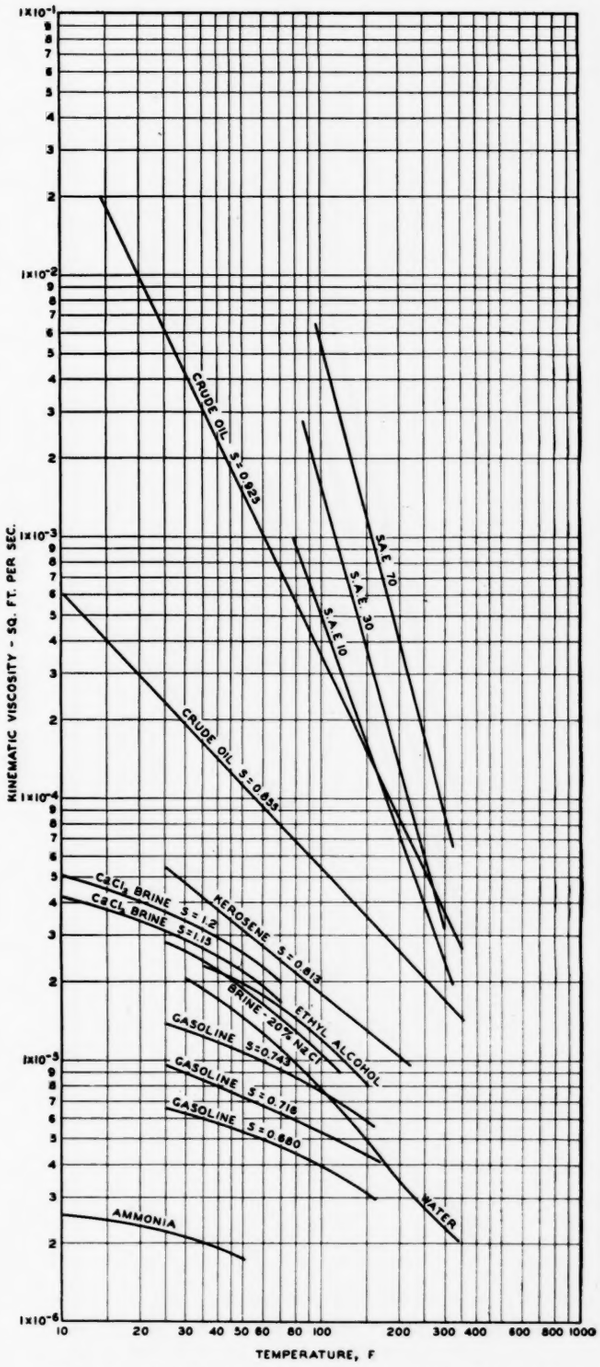


Fig. 3b. Kinematic viscosity of various fluids at different temperatures. (From Daugherty.)

Compressible Flow Equation

The more exact formula for the flow of compressible fluids is derived for perfect gases on the basis of isothermal or constant temperature flow. This corresponds to assuming that the product of pressure and volume or pressure and velocity is constant throughout the length of the pipe. This relation will also hold with sufficient accuracy for the case of the flow of steam in insulated pipes with moderate pressure drops. Table 2 lists the pressure, specific volume, and product of pressure and specific volume of steam for a range of pressures at constant enthalpy. From this table it can be seen that if there is little or no heat loss along the pipe that the product of pressure and volume will be constant over a wide pressure range within the limits of slide rule accuracy.

If the pressure drop is considerable, there will be some decrease in enthalpy as a result of the increase in velocity. This decrease in enthalpy will equal the increase in kinetic energy expressed in thermal units. Normally the increase in velocity will not be large enough to cause any appreciable error.

When the heat loss and velocity increase are large, approximate methods, taking into account the

TABLE 2

Enthalpy Btu per Lb	Temperature or Quality	Pressure, p, Lb per Sq In	Specific Volume, v, Cu Ft per Lb	Product, p, v
1189	98%	400	1.1373	455.0
1189	98.1%	350	1.300	455.0
1189	98.3%	300	1.5152	455.0
1407.7	800F	600	1.1899	714.0
1407.7	780F	340	2.110	718.0
1290	600F	600	0.9463	568.0
1290	580F	460	1.2370	568.0
1290	540F	206	2.775	566.5

effect of these factors on the velocity and density, must be used. The complicated nature of the equations of state preclude establishing any formula to take these factors into account.

The more exact formula for pressure drop which is based on the assumption that the product of velocity or volume and pressure is a constant, expressed in practical units is

$$p_1^2 - p_2^2 = .00259 \frac{f p_1 u_1^2 \rho_1^1}{d} = 87.5 \frac{f p_1 V_1^2 \rho_1^1}{d^5} \quad \ldots(4)$$

The solution of this equation for $p_1 - p_2$ cannot be made directly. It would be desirable to be able to use a simple equation such as (1) for gases and steam. The use of such an equation would not take into account changes of velocity and density along the pipe and would introduce an error.

If equation (4) which is assumed to give the actual pressure drop for compressible flow is written in the form

$$(p_1 - p_2)\,(p_1 + p_2) = 87.5 \frac{f p_1 V_1^2 \rho_1^1}{d^5}$$

or

$$(p_1 - p_2) = \frac{87.5\, p_1}{(p_1 + p_2)} \frac{f V_1^2 \rho_1^1}{d^5} \quad \ldots(5)$$

the percentage error which would result from using equation (1) for compressible flow can be determined by the following method.

$$\% \text{ error} = \frac{\text{difference in formulas}}{\text{value from approximate formula}} \times 100$$

$$= \frac{\dfrac{87.5\, p_1}{p_1 + p_2} \dfrac{f V_1^2 \rho_1^1}{d^5} - 43.75 \dfrac{f V_1^2 \rho_1^1}{d^5}}{43.75 \dfrac{f V_1^2 \rho_1^1}{d^5}} \times 100$$

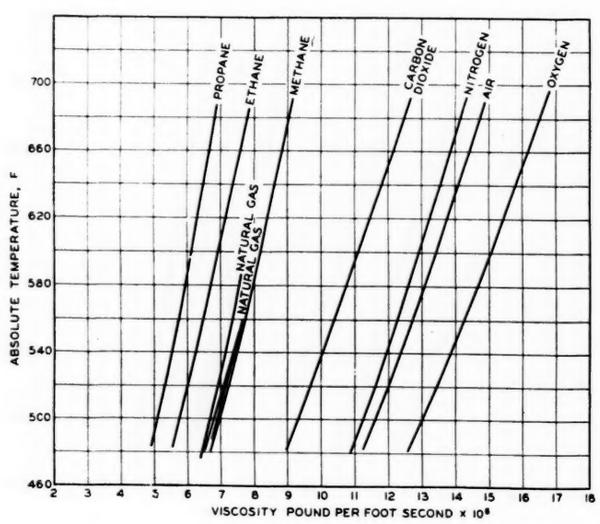
$$= \frac{p_1 - p_2}{p_1 + p_2} \times 100 \quad \ldots(6)$$

To obtain an exact value for $p_1 - p_2$ the percentage error is multiplied by the value obtained from equation (1) and this product is added to the value obtained from equation (1). The percentage error can be plotted as a single curve for all values of p_1 and p_2 if the ratio $\dfrac{p_1 - p_2}{p_1}$ obtained from equation (1) is used for the abscissa. Equation (1) may be rewritten in form

$$\frac{p_1 - p_2}{p_1} = \frac{43.75}{p_1} \frac{f l V_1^2 \rho_1^1}{d^5} \quad \ldots(7)$$

Fig. 6 is a plot of the percentage error against $\dfrac{p_1 - p_2}{p_1}$ from equation (7). Fig. 7 shows a plot of the exact value against the approximate value.

The pressure drop in pipes carrying compressible fluids can be determined by solving equation (7). This will give an incorrect value of the pressure drop, expressed as a percentage of the inlet pressure to the pipe. By the use of Fig. 6, however, the percentage error which will result by the use of equation (7) can be determined. The correct value can be obtained by applying the correction factor. The use of Fig. 7 permits the direct determination of the actual pressure drop. These curves reduce the arithmetic involved in the calculation of pressure drop required by formula (4).



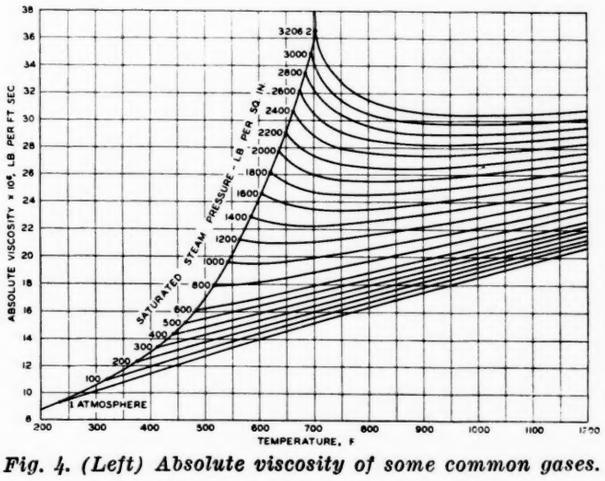


Fig. 4. (Left) Absolute viscosity of some common gases.

Fig. 5. (Above) Absolute viscosity of steam. (From Lieb.)

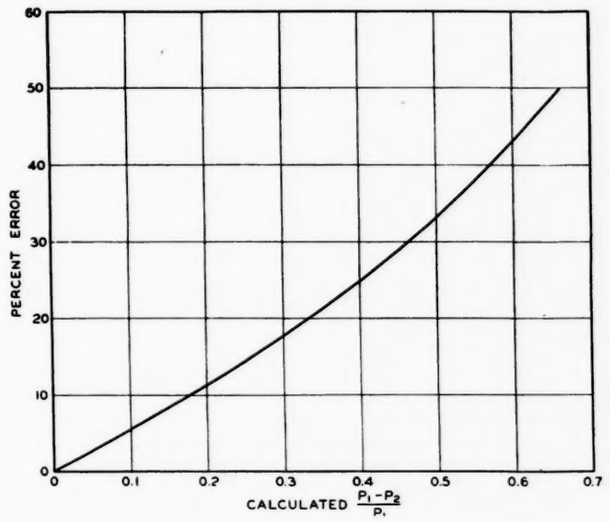
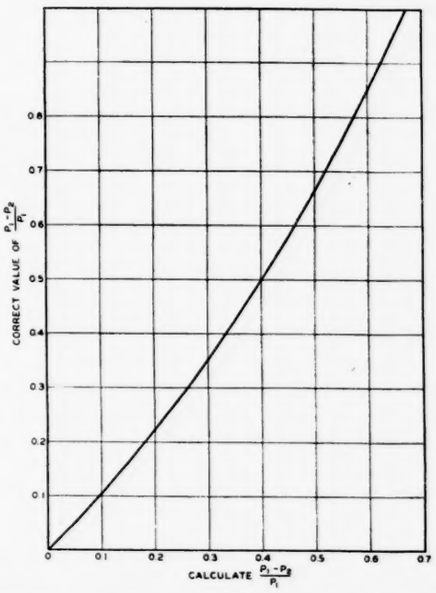


Fig. 6. (Left) Percentage error resulting from use of equation (7).

Fig. 7. (Right) Chart for determining the actual pressure drop.



Velocity Number

In many flow problems it is desirable to calculate the volume of flow which will result if a given pressure difference is applied. The velocity of flow for this case can be calculated from equations (1), (7), or (4) provided f can be determined. The value of f cannot be determined directly by using the Reynolds number since any of the forms given in equation (3) involves the rate of flow, which is not known in this case. If equation (1) is written in the form

$$(p_1 - p_2) = .00129 \frac{flu^2\rho}{d} \times \frac{d^3\mu^2}{d^3\mu^2} \times \left(\frac{.0833}{.0833}\right)^2$$

$$= \frac{fl\mu^2}{5.4\, d^3\rho}\left(.0833\frac{du\rho}{\mu}\right)^2 = \frac{fl\mu^2}{5.4\, d^3\rho} N_R^2$$

or

$$5.4 \frac{(p_1 - p_2)\, d^3\rho}{l\mu^2} = fN_R^2$$

The above expression is called the velocity number or

$$N_v = 5.4 \frac{(p_1 - p_2)\, d^3\rho}{l\mu^2} \quad \text{.....(8)}$$

$$N_v = fN_R^2 \quad \text{.....(9)}$$

Since f is a function of N_R, then N_v can be expressed in terms of N_R or if desired, f can be expressed in terms of N_v. Since this velocity number does not contain the rate of flow, it can be used to determine the friction factor when the rate of flow is to be determined. Figures 8 and 9 show a plot of friction factor against the velocity number.

Application of Formulas

The application of the methods outlined above can best be illustrated by numerical examples. The next example will deal with the determination of the friction factor and the use of formula (7) and the correction charts.

Example 2:

It is desired to know the pressure drop in a 6 inch inside diameter line carrying 150,000 lb of steam per hr at a pressure of 300 lb per sq in. abs and a temperature of 500F at the inlet. The length of the line is 400 ft.

From the steam tables we can find that $\rho = \frac{1}{1.7675} = 0.565$ lb per cu ft.

$$V_1 = \frac{1.7675 \times 150{,}000}{60 \times 60} = 73.6 \text{ cu ft per sec.}$$

From Fig. 5, we find that $\mu = 1.43 \times 10^{-5}$. Substituting these values in equation (3), we have

$$N_R = \frac{15.3 \times 73.6 \times .565}{6 \times 1.43 \times 10^{-5}} = 7.42 \times 10^6$$

It should be noted here that N_R and f are practically constant throughout the length of the pipe in spite of changes in u, since u is directly proportional to specific volume or inversely proportional to ρ, therefore the product of u and ρ is a constant. Using the value of N_R as obtained above, we can find from Fig. 2 that f = 0.0115 for a new steel pipe.

Substituting the above values in equation (7), we have

$$\frac{p_1 - p_2}{p_1} = \frac{43.75 \times 0.0115 \times 400 \times (73.6)^2 \times 0.565}{300 \times (6)^5} = 0.263$$

From Fig. 6 we find that for $\frac{p_1 - p_2}{p_1} = 0.263$ that the percentage error based on the incorrect value is 15.2%. From Fig. 7 we find that the correct value for $\frac{p_1 - p_2}{p_1}$ corresponding to a calculated value as obtained from equation (4) is 0.303. The correct value of pressure drop of $p_1 - p_2 = .0303 \times 300 = 91$ lb per sq in. The pressure $p_2 = 300 - 91 = 209$ lb per sq in. The approximate value of pressure

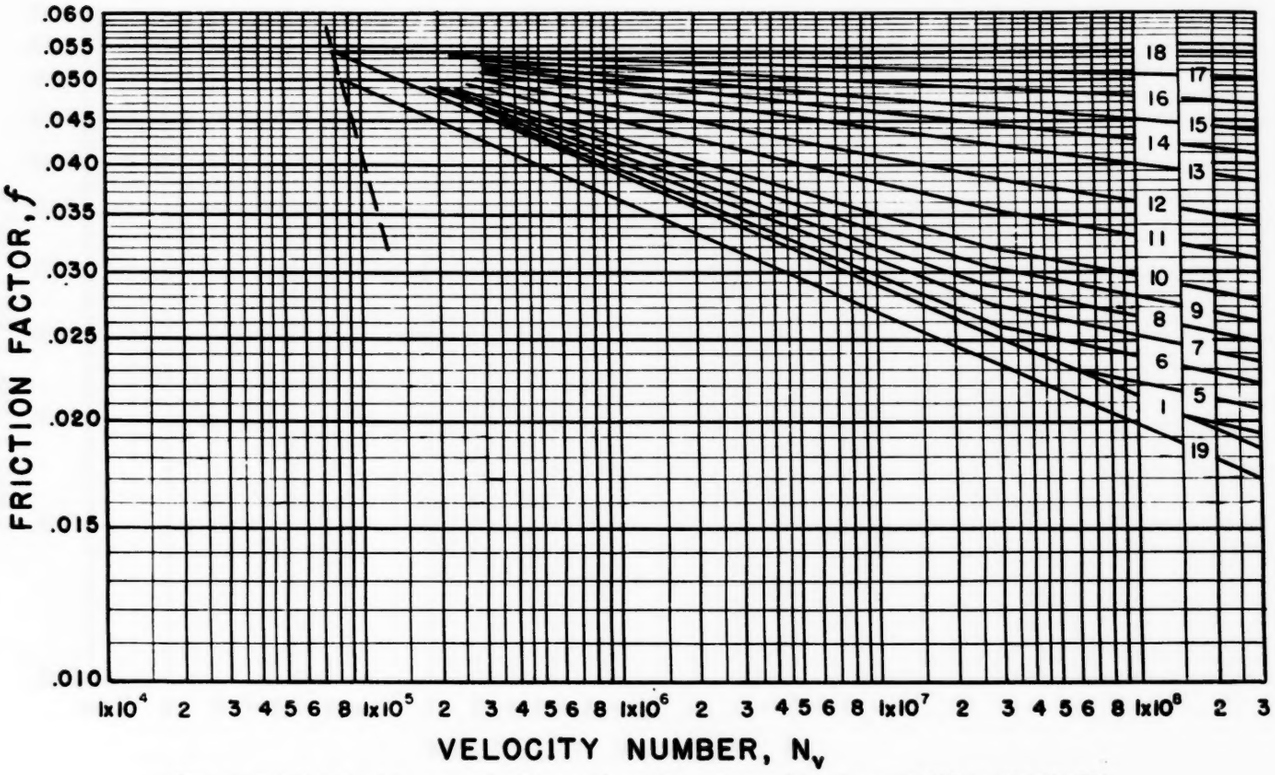


Fig. 8. Friction factors vs. velocity numbers for values of N_v from 10,000 to 100,000,000.

drop as obtained from equation (1) or (7) would have been $0.263 \times 300 = 79$ lb per sq in.

From the steam tables we find for the conditions given that $v_1 = 1.7675$, $h_1 = 1257.6$, where v is specific volume of the steam = cu ft per lb.

Then $p_1v_1 = 300 \times 1.7675 = 530$.

$$\text{Initial velocity } u_1 = \frac{V_1}{A} = \frac{73.6}{\frac{\pi}{4}\left(\frac{6}{12}\right)^2} = 374 \text{ ft per sec.}$$

The approximate final velocity assuming $p_1v_1 = p_2v_2$ and $p_1u_1 = p_2u_2$ will be

$$u_2 = \frac{p_1}{p_2} u_1 = \frac{300}{209} 374 = 557 \text{ ft per sec.}$$

The drop in enthalpy due to this increase in velocity will be

$$h_1 - h_2 = \frac{u_2^2}{2g\,778} - \frac{u_1^2}{2g\,778} = 5.75 - 2.79 = 2.96 \text{ Btu.}$$

$h_2 - h_1 - 2.96 = 1257.6 - 2.96 = 1254.6$

From the steam tables at $p = 209$ and $h = 1254.6$, we find $v_2 = 2.522$. Then $p_2v_2 = 209 \times 2.522 = 528$, which is very nearly equal to p_1v_1. For the usual conditions found in practice, p_1v_1 will be very nearly equal to p_2v_2; therefore, it is safe to assume that the so-called exact equation is accurate for the solution of practical problems.

In the selection of pipe sizes for a piping system, it is often economical to allow for a rather large pressure drop especially where the steam is finally run through a reducing valve. Such pipe lines, however, cannot carry a very large overload even with extremely large pressure drops. To illustrate this fact, we will determine the pressure drop that would be obtained in the pipe line of the previous example if the flow had been 210,000 lb of steam per hr.

$$V_1 = \frac{1.7675 \times 210{,}000}{60 \times 60} = 103 \text{ cu ft per sec}$$

$$N_R = \frac{15.3 \times 98.2 \times 0.565}{6 \times 1.43 \times 10^{-5}} = 1.04 \times 10^7$$

$f = 0.011$

$$\frac{p_1 - p_2}{p_1} = \frac{43.75 \times 0.011 \times 400 \times (103)^2 \times 0\,565}{300 \times (6)^5} = 0.474$$

% error = 31

$$\text{correct } \frac{p_1 - p_2}{p_1} = 0.625$$

$p_1 - p_2 = .625 \times 300 = 187$ lb per sq in.

$p_2 = 300 - 187 = 113$ lb per sq in.

$$u_1 = \frac{V_1}{A} = \frac{103}{\frac{\pi}{4} \times \left(\frac{6}{12}\right)^2} = 525 \text{ ft per sec}$$

$$\text{approximate } u_2 = \frac{300}{113} \times 525 = 1400 \text{ ft per sec}$$

The limiting rate of flow would be that which would result in a u_2 equal to the velocity of sound. For steam the velocity of sound is generally in the neighborhood of 1400 to 1700 ft per sec. This method

of calculation is not accurate for such extreme conditions because p_1v_1 no longer equals p_2v_2, but it does give an approximation of the limiting flow conditions and it shows that the maximum rate of flow for the pipe line in this example will be about 200,000 lb per hr regardless of pressure drop used.

Example 3:

Illustrating the use of the velocity number, determine the rate of flow of air through 500 ft of 4-inch new steel pipe when the pressure drop is 20% of the initial pressure. The initial pressure and temperature are 100 lb per sq in. abs and 100F.

First the velocity number must be determined from equation (8). In this equation μ at 100F or 560F abs from Fig. 4 will be 10.35×10^{-6} lb per ft-sec.

$p_1 - p_2 = 20$ lb per sq in.

$$\rho = \frac{PV}{RT} = \frac{100 \times 144 \times 1}{53.3 \times 560} = 0.482 \text{ lb per cu ft.}$$

$d = 4$ inch nominal or 4.026 inch actual inside diameter

$$N_v = 5.4 \frac{(p_1 - p_2)\, d^3 \rho}{l^2} = 5.4$$

$$\frac{20 \times 4.026^3 \times 0.482}{500 \times (10.35 \times 10^{-6})^2} = 6.4 \times 10^{10}$$

From Fig. 9 and Table 1, $f = 0.0146$. To determine the volume rate of flow, equation (1) may be used, but first the value of $p_1 - p_2$ to be used with this equation must be determined from Fig. 7. For a correct value of $\frac{p_1 - p_2}{p_1} = 0.20$, we find the value of $\frac{p_1 - p_2}{p_1} = 0.183$, that is, $p_1 - p_2 = 18.3$ lb per sq in. should be used in equation (1).

Solving equation (1) for V

$$V = \sqrt{\frac{(p_1 - p_2)\, d^5}{43.75\, f l \rho}} =$$

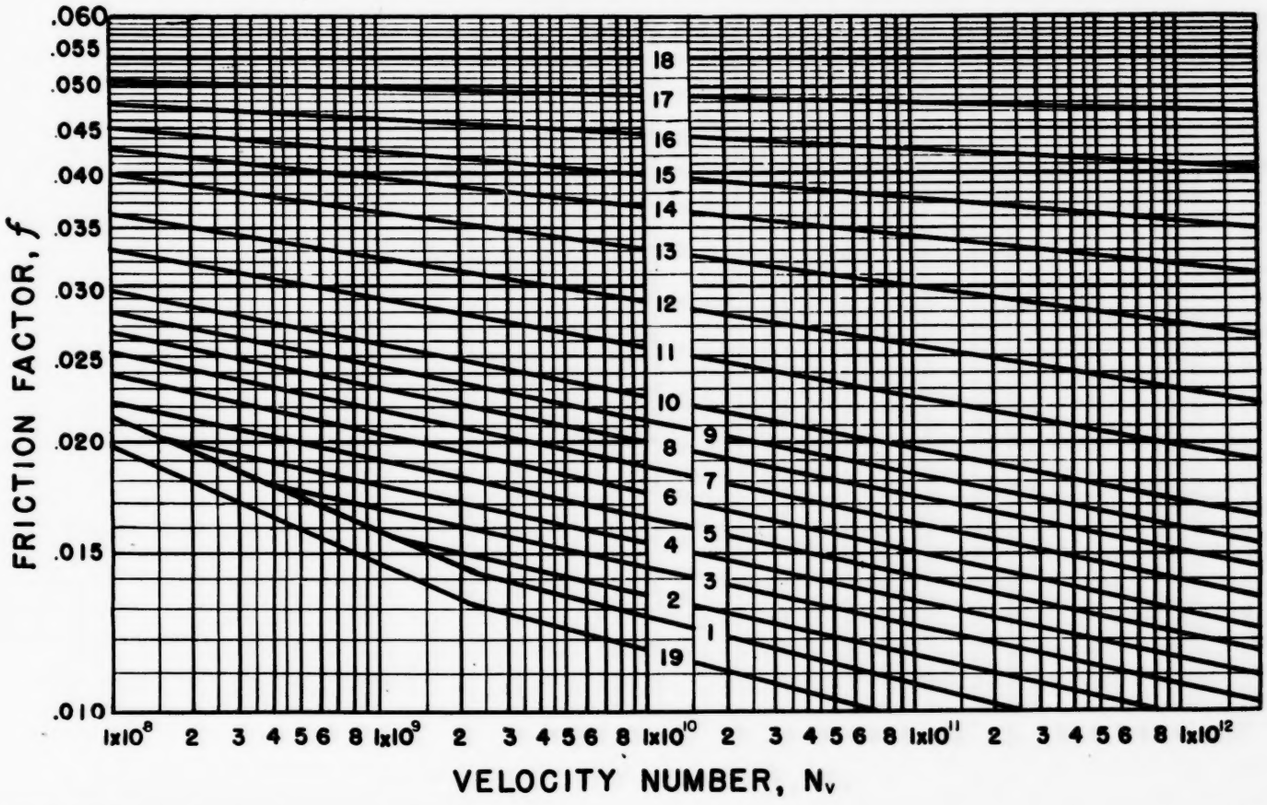
$$\sqrt{\frac{18.3 \times 4.026^5}{43.75 \times 0.0146 \times 500 \times 0.482}} = 126 \text{ cu ft per sec}$$

measured at inlet conditions. The weight rate of flow is $W = 0.482 \times 126 = 60.6$ lb per sec.

Summary

The foregoing material gives in a very condensed form all the information and methods which are necessary to make calculations for pressure drop in piping systems. As has been pointed out, the friction factor curves can be used for any type of fluid which might be encountered provided its viscosity and density are known. Likewise the curves can be used for any type of conduit provided the relative roughness is known. Table 1 lists the ordinary types of rough conduits which are encountered. The velocity number which is introduced in this article affords a very simple means for making calculations where rate of flow is to be determined. The method for making compressible flow calculations should be quite a simplification over conventional methods which have been used.

Fig. 9. Friction factors vs. velocity numbers for values of N_v from 100,000,000 to 1,000,000,000,000.



WASHINGTON NEWS

summarized by Loring F. Overman.

Production Program Enters New Phase; Amended L-79 Questions and Answers; Add to Defense Housing Critical List.

The war production program has entered a new phase in which the output of civilian industries will be restricted, not as in the past by limitation and curtailment orders, but by concentration of production in certain plants and regions.

These industrial units will be known as *nucleus plants*. They will be allowed to continue operation near capacity to supply civilian demands.

Concentration of civilian production raises many difficult problems, such as compensation to closed-down firms, maintenance of trade-marks, rearrangement of distributive systems, and so on.

But while these are of great importance to the firms involved, it was pointed out by Donald Nelson that from the standpoint of war production they are secondary to the need for determining the degrees of curtailment, concentrating production, and converting non-nucleus firms to war work.

In the selection of nucleus plants, WPB will be guided by the following conditions:

1. As a rule, small plants will be kept in civilian production, and large plants which are equipped to handle war work, will be required to suspend civilian production;
2. Civilian plants will be suspended in areas where labor is urgently needed in war plants, and nucleus plants will be selected in areas where there is a surplus of labor. Many rural communities fill this condition;
3. Nucleus plants will be selected so that cross-hauling is eliminated and the drain on transportation facilities is reduced;
4. Civilian plants will be suspended or restricted in regions where the power supply is likely to be inadequate; and
5. As a rule nucleus plants will not be located in areas where warehouse facilities are short.

WPB will set up a program for nucleus plants which will endeavor to prevent domination of an industry by one or two firms after the war. A plan is under study for compensation to closed-down firms whereby firms which continue operations provide payment. This would include either an agency scheme, under which nucleus plants produce at cost for closed-down firms which retain their sales organizations, or a pooling scheme which concentrates both production and distribution in the nucleus firms.

Smaller War Plants

Closely related to the nucleus plant program is the Smaller War Plants Corporation, created within the War Production Board recently by an act of Congress. This agency, which the heating and air conditioning industries were active in supporting during the Congressional campaign, is headed by Lou E. Holland, of Kansas City, president of the Double Rotary Sprinkler Corporation. The functions of the Smaller War Plants Corporation will be:

1. To confine manufacture of relatively simple war items to the smaller factories, using the large plants exclusively for the complicated and difficult items which cannot be made in the small plants;
2. To extend sub-contracting, both through the use of pool and through much greater emphasis on the farming-out of manufacture of bits and pieces by large corporations which hold prime contracts; and
3. To convert small plants to essential civilian production. Many plants now producing non-essential items will be brought into this program.

The Smaller War Plants Corporation has the power to accept prime contracts from war procurement agencies. It can take these contracts and split them up, sub-contracting with small business firms for the production of component parts. It will be able to deal effectively with pools, not only because it can itself take these prime contracts, but because it can help provide the pools with engineering and financial assistance. It will help manufacturers to reconstruct old machinery and in certain cases help manufacturers acquire new machinery.

The Air Conditioning industry is represented on the board of directors of the Smaller War Plants Corporation by William S. Shipley, chairman of the board of the York Ice Machinery Corporation, York, Pa.

Another change in the production program during July was the realignment of WPB which eliminated many of the overlapping agencies. Shortage of materials will now be given major attention. Production was the main problem previously. Efficient control over allocation of materials will be emphasized and inventory control will be an increasingly important development. Greater use will be made of industry advisory committees.

Against this background of war production changes, WPB made several alterations in regulations affecting the heating and air conditioning industries.

Amended P-126

P-126 was amended July 9 to extend the high preference ratings for emergency repairs to commercial air conditioning and refrigeration equipment provided under the original order, to September 30. The provision expired June 30 and the extension is retroactive to that date.

Ratings ranging from A-1-a to A-8 are provided under P-126 for various types of emergency repair service by designated emergency service agencies. It also permits suppliers of these agencies to use the ratings.

The amendment provides that suppliers may extend the ratings subject to the conditions of Priorities Regulation No. 3 as amended. The amendment also makes certain technical changes in the original order, the effect of which is to write into the body of the order the restrictions on application of the ratings by Emergency Service Agencies which formerly were a part of the endorsement that these agencies were required to attach to their purchase orders.

A new paragraph provides that an emergency service agency may not apply any preference ratings assigned by the order until he has shown to each supplier from whom he obtains delivery of materials the certificate of authority to operate under the order issued by the Director of Industry Operations. The supplier also is required to see the certificate before he makes delivery.

Ruling on Ducts

A schedule of maximum prices for Formdux, composition duct material developed by Chrysler Airtemp to replace vitally needed metals, was established by OPA July 14. A sug-

gested list of prices as submitted by Chrysler has been tentatively approved subject to revision when complete cost of production figures are available.

"While we do not have sufficient information, as yet, to give final approval to the list of prices and discounts submitted for this product," Leon Henderson stated, "the establishment of tentative maximum prices will permit the immediate sale and delivery of the composition duct developed by Chrysler Airtemp Sales Corporation and will result in the saving of thousands of tons of metals in defense housing and other government financed construction, as well as in private construction."

The list prices submitted by the company are commensurate with competitive products, especially as the company has established field offices to service jobbers, wholesalers, and contractors, furnished advertising and promotional aid and maintains other services over and above those normally undertaken by a distributor, the Price Administrator said.

Catechism on Amended L-79

WPB issued the following question and answer interpretation of the relaxations of L-79 as recently amended:

Q. Are the following items restricted by the definitions of the order: Breeching, flue pipe, air ducts and fittings? A. No. Q. Salvaged or damaged new materials? A. Yes. Q. Obsolete fixtures? A. Yes, if new. Q. Circulating heaters or other space heaters? A. Yes, to the extent provided by paragraph (A) (2) (v) of the order.

Q. Is a fireplace heater construed to be a space heater within the intent of the order? A. Yes. Q. Is damaged or defective new equipment considered to be "used"? A. No. It is still new material.

Q. May a manufacturer sell new metal heating equipment to a wholesaler without an A-10 rating? A. He may sell without restriction to anyone except an ultimate consumer.

Q. May a wholesaler or jobber sell new metal heating equipment to a retailer without an A-10 or better rating? A. Yes, he may sell without restriction to anyone except an ultimate consumer.

Q. May a person replace an existing oil fired furnace or boiler, with a coal burning furnace or boiler, or add a separate unit under paragraph (b) (8)? A. No. This paragraph covers only parts for conversion.

Q. May orders undelivered as of April 16, 1942 be filled? A. Yes, if they were bonafide orders booked prior to April 17, 1942, provided delivery was made not later than June 30, 1942.

Q. May new heating equipment be installed under paragraph (b) (6) without a rating if there is no such equipment available currently in the building? A. This exception applies only to cooking stoves, heating stoves, and water heaters, and is limited to a place of residence. The customer must sign the certificate specified in Order L-79 as amended.

Q. May a restaurant obtain a range, water heater or space heater under paragraph (b) (6)? A. No, because a restaurant is not a residence.

Q. May a person install a gas automatic water heater under paragraph (b) (6) or paragraph (b) (8) to replace, or add to, an existing oil fired summer-winter hookup, water heating equipment? A. No, except in the case where the oil fired summer-winter hookup has been converted to burn coal, thus rendering the summer-winter hookup impracticable. In this case, he may install a separate water heater under paragraph (b) (6).

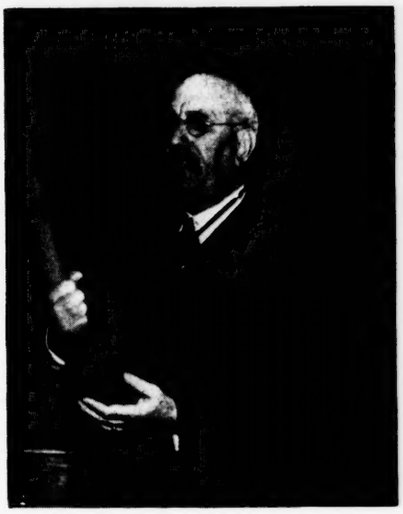
Q. May an ordinary water heater or fixture which is to be used for specific hospital purposes be sold under paragraph (b) (3) (ii)? A. No. Only equipment specifically designed for the use described in the order.

Q. Is the sale of an oil storage tank excepted if specific appeal under M-68 has been granted? A. No.

Q. Is the sale of gas burning warm air furnaces restricted? A. No. Only coal or oil burning furnaces are restricted.

Q. A person has an oil-fired water heater in his residence, but because of the oil shortage is unable to secure further supply of oil for same. May he purchase a gas water heater by using the certificate shown in paragraph (b) (6)? A. Yes.

Q. Are unit heaters including gas unit heaters construed to be space heaters under the terms of the order? A. No.



William S. Shipley of the Board of Directors, Smaller War Plants Corporation.

Q. What is the correct definition of space heaters as used in Order L-79? A. "Space heaters" as used in L-79 as amended, means any above the floor device, except unit heaters, using coal, oil, or gas as fuel for direct heating of the space in and adjacent to that in which the device is located, designed for use without heating distribution pipes or ducts as integral parts of such heating devices.

Q. Is the sale of coal burning boilers and coal burning furnaces restricted? A. Yes.

L-41 Amended

Under an amendment issued July 23 to L-41, which controls non-essential construction, owners are permitted to begin reconstruction of certain types of non-residential construction, damaged or destroyed after date of the amendment, provided the restoration is necessary for the prosecution of the war or to protect public health and safety.

Construction authorized in the amendment is defined as all construction other than residential and agricultural, including commercial, industrial, recreational, institutional, highway, and utilities. To restore "other restricted construction", however, the builder must notify WPB by telegraph within five days of the damage, setting forth the cause of destruction, function of the damaged structure, estimated cost of reconstruction, and reasons immediate reconstruction is necessary. This notice must be followed within two weeks by application for authorization of reconstruction on the usual form, Pd-200. There is no commitment, however, that priorities assistance will be granted and the WPB may at any time order construction to stop.

P-19a-h Amended

Contractors and builders are permitted to get "expendible materials" under an amendment to P-19-a and P-19-h. The amendment, issued July 7, allows the builders operating under the two project ratings to use the ratings assigned under the order to obtain such items as perishable tools, forms, scaffolding, and the like which were not previously incorporated in the order. Builders formerly had to file PD-1a applications to obtain these expendible materials. The liberalization of the order does not cover fuel, construction machinery or repair parts for construction machinery.

Heating Charges

Application of the General Maximum Price Regulation to charges for pre-cooling, icing, ventilating, and

heating of shipments and of transportation equipment have been postponed until Aug. 1. The ceilings were originally effective July 1.

New Defense Housing Areas

WPB added the following new areas to the Defense Housing Critical Area list during July: Alliance, Ohio; Sterlington, La.; Decatur, Ala.; Bishop, Calif.; Dos Palos, Calif.; Bay City-Midland, Mich.; Miami, Okla.; Hemet, Calif.; Deep River, Conn.; Leadville, Colo.; La Junta, Colo.; Greenwood, Miss.; Cumberland, Md.; Emporium, Pa.

Fernald Dies

John M. Fernald, chief of the air conditioning and refrigeration branch of WPB, died July 27 in the Veterans Hospital at Mount Alto, Md., after a brief illness. He was 52 years old.

Harry C. Williams, assistant chief of the branch, has been acting chief during Mr. Fernald's illness.

Formerly general manager of the Baker Ice Machine Company of Omaha, Mr. Fernald came to Washington in November to serve with WPB. He was with the contract distribution division, as chief of its contract and placement service until the organization in March, under his direction, of the air-conditioning and refrigeration division.

From 1936 to 1938 he was president of the Refrigerating Machinery Association, which combined in 1940 with the Air Conditioning Manufacturers' Association under the name of the Air Conditioning and Refrigerating Machinery Association, Inc.

Mr. Fernald was born in Newtonville, Mass., and educated at the Hawley School of Engineering.

In 1917-19 he served with the United States Army Engineer Corps, and after the first World War, became sales engineer for the Cutler-Hammer Manufacturing Company in Boston.

He leaves a widow, a sister and an aunt.

A.C. Committee

Formation of a 13-man Industry Advisory Committee for Industrial Refrigeration has been announced by T. Spencer Shore, chief of the Division of Industry Advisory Committees, WPB. The chief of the Air Conditioning Branch, WPB, will be government presiding officer.

Members are: W. H. Aubrey, Frick Co.; F. H. Faust, General Electric Co.; D. F. French, Carrier Corp.; G. A. Heuser, Henry Vogt Machine Co.; H. F. Hildreth, Westinghouse Electric & Mfg. Co.; F. D. Kirk, The Vilter Mfg. Co.; O. Z. Klopsch, Wolverine Tube Division, Calumet & Hecla Consolidated Copper Co.; Charles Knox, Baker Ice Machine Co.; Marshall G. Munce, York Ice Machinery Corp.; G. E. Wallace, The Creamery Package Mfg. Co.; K. A. Weatherwax, Acme Industries, Inc.; C. E. Wilson, Worthington Pump & Machinery Corp.; P. B. Zimmerman, Airtemp Div., Chrysler Corp.

FUEL SITUATION

(Concluded from page 34)

still in effect. He emphasized that the restriction was lifted, not because the Northwest has all the fuel oil it needs but, rather, to take advantage of all available storage space to provide some protection against unforeseen developments.

"At the present time, sufficient tankers are available to fill the fuel oil storage tanks," Mr. Davies said. "But this does not mean that the tankers will continue to be available. At any moment, they may again be called into military service."

Though the 50% curtailment on deliveries has been lifted in the Northwest, operators who have standby facilities burning fuels other than oil must continue to operate the standby facilities on a full-time basis, using the oil burners only for emergency purposes.

New England Developments

Coal dealers of New England report they are doing the biggest summer business since oil heat came in, with 50% of their regular customers already supplied with bins full, compared with the normal delivery of only 10% of the season's supply of fuel from April 1 to July 1. It is expected that the season will bring 10,000,000 tons more business than last year.

The plan of Boston's Mayor Tobin to convert residential oil burners to coal in the face of the serious fuel oil shortage appears doomed to quick failure, as the Boston office of OPA told inquirers that priorities make it impossible for the public to get conversion equipment.

However, Mayor Tobin's committee, consisting of Fire Commissioner William Arthur Reilly, Building Commissioner James Mooney, June Richdale, vice president of Colonial-Beacon Oil, F. F. Nelson, Petroleum Heat & Power and Albert L. Nickerson of Socony-Vacuum are busy working out a questionnaire to be sent to every home owner in Boston with oil heating equipment to determine whether their furnaces can be converted to coal. The defense plants now using oil have made their own survey and these will be considered together with the homeowner questionnaires and answers.

Added to the troubled situation is the fact that six Massachusetts institutions, including the State House and six hospitals, now consuming a total of 7,575,000 gallons of oil yearly, will not be granted priorities for material for conversion.

Credit Eased

An important development in aids to conversion was the move by Federal Reserve Board on July 27 in liberalizing credit restrictions on conversion and conservation measures.

The board will no longer require down payments or repayments within a limited term of months in connection with the conversion of heaters, installation of weatherstripping or insulation or other devices to conserve fuel. Dealers and contractors will be at liberty to establish whatever requirements they choose.

Under previous Federal Reserve regulations, if conversion were financed on the installment plan it would have to be paid for one-third down and the balance in twelve months.

The new regulation, an amendment to Regulation W, affects stokers, storm doors, storm sash, rock wool, weather stripping and all other materials used in connection with fuel conservation.

Stokers were formerly classified under Group A of the regulation and were restricted to a down payment of one-third the purchase price and a maximum maturity of 12 months. These two requirements are now removed, but *only where the stoker is installed in connection with an oil conversion job.*

Regulation W previously required 12 months maturity on contracts covering insulation equipment. The amendment removes this restriction. The materials excepted from the regulation are those commonly identified with insulation. The list, for instance, does not include roofing. It is limited also to equipment for existing structures.

In some instances, it is recognized, oil burning plants may be replaced by heating stoves or space heaters. These units are classed as new equipment and are not affected by the exception to Regulation W. The terms remain at one-third down and 12 months maximum maturity.

Is *This* Tomorrow's Method of Heating and Cooling?

By CARL F. BOESTER

Director Housing Research, Purdue Research Foundation, Purdue University.

The ideas expressed by the author in the accompanying article are those of an engineer who, in spite of progress in the art made to date, is still dissatisfied with existing methods. Since radically new methods or technics are usually found to have at least some disadvantages or opposition, or unsolved problems that work against their immediate and widespread adoption (prefabricated housing, for example), the case for Mr. Boester's proposals may not be quite so one-sided as it appears. Perhaps he has overstated the case. Nevertheless, we believe every reader will want to be acquainted with the theories advocated by the author.

TO many people the term *air conditioning* applies to the processing or the treatment of air to produce a desirable degree of comfort in the summer time. However, to the more initiated the term air conditioning applies equally well to the maintaining of desired human comfort in the winter time. With air as the agent of convection or the means of heat exchange whereby human comfort is made possible, three factors have to be reckoned with by engineers in the maintaining of winter or summer comfort. These are air temperature, air moisture, and air motion (not considering for the moment the factor of air cleaning), and it is the proper balancing of these factors or their relation to one another that is responsible for the sensations of comfort experienced by human beings in enclosures where air conditioning has been applied.

After considering some of the earlier means of providing human comfort, many would be inclined to believe that air conditioning, like radio and aviation, has been one of the truly great wonders and blessings of the twentieth century. But perfection has not yet been attained; air conditioning is certainly expensive in first cost and far from economical in operating costs, regardless of whether it be summer or winter comfort that is being produced and maintained.

One of the principal factors in maintaining human comfort is the element of air moisture. Many engineers feel that, to provide winter comfort, some adjustment of air moisture is essential. But so far, physicians and physiologists have not been able to find any evidence of improved physical well-being as a result of adjustments in air moisture; and if during the winter time the air moisture is increased, then surely operating costs are increased, because it takes energy to support this moisture in the air. In the summer air moisture is again a prime problem, in that it accounts for between fifty and seventy-five percent of the total refrigeration energy required in the reduction in the amount of air moisture in order to provide summer comfort. So, in spite of tremendous advances in air conditioning in recent years, to be comfortable during the summer still is a luxury even to the rich. Only in commercial establishments such as stores or theatres can the average person avail himself of the benefits—for a limited time—of summer air conditioning.

Only in commercial establishments such as stores or theaters can the average person avail himself of the benefits of summer air conditioning.

But to some, particularly older people with a retarded rate of metabolism, summer air conditioning is not always an unmixed blessing. Why? Simply because of the reactions that occur upon entering and leaving enclosures that have been air conditioned. A person who has been outdoors on a hot day will find that his heart is busy pumping large volumes of blood through all parts of the body in an endeavor to help maintain a degree of comfort. The blood vessels and arteries are wide open, and the heart is operating at increased speeds. Immediately upon stepping inside an air-conditioned enclosure, the hundreds of little thermostats embedded in the skin, sensing the temperature change, practically instantaneously, restrict the blood veins, vessels, and arteries much more quickly than the heart can respond, so that the heart is placed in the position of pumping against a restricted system of piping. This imposes a tremendous overload on the heart. It is needless to say that every time one enters such an enclosure, whether he is old and feeble or young and healthy, his heart takes punishment. There is also a distinct and unpleasant jar to the nervous system when one enters a cool enclosure from the warm outside. This frequent jangling of the nerves probably doesn't contribute to anyone's overall welfare.

Another reaction takes place upon leaving such an enclosure. When one steps outdoors, the blood-circulating system, in response to orders from the thermostats in the skin, opens wide, while the heart is pumping blood at a much reduced rate. Since the one leaving such an enclosure is always standing, the blood rushes from the head and the brain and in extreme cases the person momen-

tarily loses consciousness. This temporary fainting may result in injury by fall; or if one be crossing the street and be subject to merely a partial reaction of this type, the temporary loss of faculties might be responsible for a serious accident with vehicles moving on the street.

All in all, this isn't entirely desirable, and it is questionable whether or not the satisfaction of comfort, once a person is over these brief yet harmful effects, is worth the cost. Serious consideration has been given to other methods of producing human comfort without these bad effects, and at the same time with a lower first cost and a lower operating cost. For example, a widely-known physiologist, Dr. C. A. Mills, of the University of Cincinnati, has made experiments on animals and human beings under different conditions of environment, and in 1937 he suggested before the American Society of Heating and Ventilating Engineers that human comfort could be provided and controlled entirely by radiant means alone, independent of air temperature, air moisture, or air motion. He suggested several ways that this might be accomplished. Not being an engineer, he could only say what the requirements should be, not how they might be achieved mechanically.

The physical accomplishment of Dr. Mills' theory involves the employment of one type of energy—radiant energy. Radiant energy passes through the air without affecting the temperature of the air through which it moves. The particular wave lengths involved in the production of summer comfort and winter comfort are in that portion of the spectrum that is invisible, yet this energy has many of the characteristics of light.

If human comfort is to be provided by radiant energy alone, just how is it to be used and how can the factors of air temperature, air moisture, and air motion be ignored in keeping comfortable? Well, to begin with, assuming for the moment that we are endeavoring to keep warm in the winter time, we must realize that no heating system as such is a heating system. It is simply a device for controlling the rate at which the body loses heat, for winter or summer the body must give off on the average about four hundred Btu's of heat per hour. If the body loses heat faster than this rate, it has the sensation known as a chill.

In the present-day art of producing human comfort by means of air conditioning are several factors that are important in the capacity of the equipment required to maintain comfort and in the operating costs of such equipment. In the winter time, of course, the occupant has the advantage of his own heat to help maintain a balance of comfort, but the load on the air-conditioning plant is many times greater than the actual requirements of the occupant; and the sources of this demand are the enclosure-heat loss and the ventilation-heat loss. The present practice is to keep the air in an enclosure about seventy degrees in temperature regardless of outdoor temperature. This means that there is a substantial temperature difference between indoors and outdoors, with the result that the heat loss or heat flow from the inside to the outside of a building is very substantial. Since this loss is so great, the amount of energy required to maintain this temperature inside must of necessity be great. Every cubic foot of air required for ventilation that is brought in from the outside must be heated, and the energy requirements for this purpose are also large. The result is that the capacity of the equipment to produce comfort becomes large and thereby costly; and the energy requirements of fuel are great and therefore the operating cost is high.

In the winter time the load on the air conditioning plant is many times greater than the requirements of the occupant.

Let us assume for the moment that the house of the future will have no building-heat loss and no ventilation air heating loads, and that the air temperature inside the house is to be the same as that of the air outside the house. If today, for example, it is ten degrees above zero outdoors, it could be ten degrees above zero inside. If this is so, there can be no building-heat loss because there is no temperature difference. With no temperature difference, the house of the future need not be insulated; the walls and roof would serve only for protection from the elements—the wind, the rain, and the snow—and they might therefore be simply a sheet of aluminum over a light aluminum framing. Since the air for ventilation does not have to be warmed up to a temperature above that of the outdoors, ventilation-heat loss ceases. All air required for ventilation, however, is very carefully filtered and sterilized by ultra-violet rays or the like so that sanitary ventilation will be the new order.

Well, what about the occupants? They are still going to give off their four hundred Btu's of heat every hour, more or less. A great percentage of the energy will be lost by radiation to the surfaces enclosing the occupants. By careful treatment of the walls and ceilings of the enclosure, this radiant energy will be redirected or reflected back to the occupants, so that their own heat in part helps to keep them warm. However, in this house of the future, since the air temperature at times may be very low, the occupant's energy is not entirely adequate; in the normal process of breathing, every cubic foot of air that is inhaled must be warmed up to an approach to body temperature, so that at times there is imposed on the body a very great heat loss in this manner. The object, therefore, would be to balance this heat loss in some way. One way, of course, would be by increasing the rate of metabolism or by the assimilation of heated foods. This is not entirely practicable.

The solution, therefore, would be the placing in the enclosure of a source of radiant energy, which would radiate heat to the occupants in the amount

required to establish the thermal balance necessary for comfort. This radiant energy would be diffused all around the room, and because of the reflective characteristics of the surface of the enclosure, which are reflective only and particularly in that range of wave lengths required for comfort purposes, regardless of where the occupant is, standing, sitting, or lying, sufficient energy would reach him for comfort. The walls of the enclosure would be at least ninety percent reflective to the wave lengths required, so that there would be very little heat loss from the source of radiant energy over and above that required to maintain the thermal balance of the occupant or occupants.

The mechanical characteristics of this source of radiant energy can take almost any shape. Almost any fuel may be utilized—coal, oil, or gas—but electricity would seem to be the most desirable, because only a trivial amount of it would be required to keep the occupants comfortable. The other fuels could be converted at their source of supply into electricity, and there would no longer be any need for expensive central-heating plants and the expensive cost of distribution of such fuels, to say nothing of the fact that with the elimination of central-heating plants in the homes of the future there will no longer be smoke palls over all our cities. With smoke eliminated, many of the present-day respiratory diseases that are killing off thousands of people annually will be a thing of the past.

The question now arises — what about summer comfort? With the walls of an enclosure so treated as to be reflective in character, and particularly to return the occupant's heat to him, surely in the summer he will go up in smoke, being unable to get rid of all of his excess heat by evaporation of perspiration and a modest amount by convection. Well, this radiant energy also works in reverse, and we shall employ it as a means of producing summer comfort. Again the air inside is the same temperature and moisture content as outside. If the air outside is one hundred degrees in the shade, it is one hundred degrees in temperature indoors. So when you walk from indoors to outdoors or outdoors to indoors you will not experience sensations of chill or shock, and there will be no physical harm to your body or its parts.

Because the walls are high in reflectivity and low in emissivity, only a tiny portion of the solar heat gain gets to the inside and is emitted from the inner surfaces of the enclosure; and this is kept in balance by a modest circulation of air for ventilation, so that indoor and outdoor temperatures are kept in equilibrium. Now instead of an energy-radiating device, we have an energy-absorbing device; and it is so built that, as we radiate energy from our bodies, it is picked up by the radiant heat-absorbing surface in the room—some of it directly from our bodies and some of it by radiation from our bodies to the reflective walls and ceilings. The heat-absorbing device will be nothing more than a very low temperature surface, adequate in capacity to absorb the energy radiated from the body in sufficient quantities to maintain that thermal balance required for comfort. This low temperature surface will be operated by fractional-horsepower refrigeration equipment, and the surface will be protected by double or triple glazing of a special type of plastic, which is transparent to the radiant energy in the particular wave lengths required. By such double glazing the moisture in the air cannot be condensed and deposited on the cool surface and be an additional burden on such heat-absorbing surface.

Will the occupant go up in smoke, being unable to get rid of all of his excess heat?

Thus, in this way summer comfort is produced independent of air temperature, air moisture, and (nearly independent of) air motion, at a fraction of present-day costs, because again there is no building-heat gain or ventilation load to take into consideration. It is simply an establishing of the thermal balance according to the number of occupants in the enclosure.

Two of the advantages of this particular means of producing year around comfort are that it will be low in first cost and extremely low in operating costs, and that it can be applied to existing buildings as well as new buildings at a fraction of the first cost as compared with present-day means of providing human comfort.

There are, of course, many things to be taken into consideration when applying this new method of providing human comfort, but all such questions have been anticipated and more or less satisfactorily answered. What about water pipes? Insulated, of course, against freezing in the winter time, as pipes are required to be insulated in present unheated areas of buildings. The toilet will freeze? Why not use a frost-proof toilet? Your plants, flowers, and the like will perish? Yes, unless you keep them in a heated glass greenhouse; but it will not be necessary for the plants to be so protected if the radiant energy is on all the time in the room in which the plants are placed. Of course, the technician will raise the point—what effect have the openings of an enclosure, such as windows and doors? These will be treated in such a way that light can come in through the windows as well as air for ventilation, and yet the radiant energy will be reflected from the window areas in the same way as it is from the walls. What about when you are seated at a table or desk? The inner surfaces of such a table or desk will be reflective in character, so that there should be no difficulty from this source.

One particular advantage of this type of heating or cooling would be that it is instantaneous in character, and therefore it is not necessary to have the energy turned on when there are no occupants in the room. For instance, when the entire family is away in the evening for a movie, all sources of radiant heating or cooling are turned off. Therefore, there

is not the expense of such operation, as with present-day heating systems, when it is required to keep them going whether there are occupants in the house or not. This fact tremendously affects operating costs. The energy can also be turned off and on in the various rooms as occupants move from one part of the house to the other.

Such a method of heating and cooling will have far-reaching effects on methods of building new houses. Perhaps the home of the future will have nothing but curtain walls for the outside, which will consist of nothing more than a porcelain-enamel steel sheet, a sheet of aluminum, or a sheet of exterior-grade plywood. The only protection will be from wind, rain, and snow; for as previously mentioned, this technique is independent of air temperature, air moisture, and air motion.

With fundamental changes in building practices and techniques resulting from the war, it is possible that this new technique in producing human comfort may be available much sooner than many realize. At least a half-dozen research laboratories are conducting elaborate experiments in this method of producing human comfort, including the facilities available to the author, and the time does not look too far off when this principle will be the new order in heating and cooling. It is to be realized, of course, that much of this work is still along theoretical and idealistic lines, but so much has been accomplished that, as suggested, it may become a general practice sooner than many realize.

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As a matter of fact, equal or greater comfort can be established with some of the better-known practices of heat exchange, as forced hot water through convectors, steam through free-standing radiators, or a well-designed gravity or forced warm-air heating system; and this comfort can be achieved equally well by these methods at a saving in initial cost and, in many cases, lower operating costs. In the writer's opinion, all claims for operating economies of the various types of surface or panel heating systems over well-designed systems of conventional character are fictional. A house has a given heat loss, and regardless of what you do mechanically, you can't reduce this heat loss. Boiler efficiency is not changed one bit when you heat water in it and pipe it through coils in the floor or whether the water is heated in this same boiler and distributed through properly-placed convectors throughout the house. Claims for greater comfort of so-called panel- or floor-heating are fiction of the rankest sort, because houses identical in floor plan and identical in heat loss can be heated by conventional means with the same mean radiant temperature conditions being achieved; and it will be impossible for an occupant, if blindfolded, to tell whether the house he is in is heated by panel-heating methods or by more conventional methods.

The heating engineer and contractor is making a serious mistake in recommending panel heating unless ways and means are devised for producing winter comfort by panel heating at a lower first cost to the home buyer. On the other hand, the heating man is certainly advised to become aware of how all-important the temperatures of the surfaces of the various rooms of a house are. In order to provide good comfort and economy in the sizing and installation of his equipment, he should, in addition to determining air temperature, air moisture, and air motion, determine what mean radiant temperature will prevail. For the next few months or years he should study all he can about the production of human comfort — winter and summer — by radiant means alone, independent of sometimes hard-to-control factors of air temperature, air moisture, and air motion, always bearing in mind that true radiant heating is accomplished by reflection from the surfaces of an enclosure and not by emanation of radiant energy from one of the surfaces of an enclosure. In a well-designed radiant heating and radiant cooling system, the source of radiant energy will be independent of the surfaces of an enclosure. The heating source will probably be part of a lighting fixture. The radiant-heat-absorbing surface for cooling might logically be concealed by a cove or moulding at the ceiling line.

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"It is the aim of the ASHVE to coordinate the efforts of all interested organizations in the heating industry in the utilization, production, distribution and transportation of fuel. With such a unified presentation of facts, common sense will virtually dictate to the home owner that it is prudent to 'War on Fuel Waste' as it is not only a patriotic duty, but it also results in personal savings."

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ASHVE Hears Papers on Blackout Plants, Panel Heating, at Semi-Annual Meeting in St. Paul

ST. PAUL—The semi-annual meeting of the American Society of Heating and Ventilating Engineers held here June 15-17 attracted two hundred members and guests. Topics of value to the engineers devoting their time to the war effort were discussed at length.

The first paper presented was on the performance of a forced warm-air heating system as affected by changes in volume and temperature of air recirculated and was prepared by Professors A. P. Kratz and S. Konzo, University of Illinois. This paper, presented by Professor Kratz, was the result of a two-year investigation revealing seven significant factors in the performance of a forced warm-air heating system under stoker operation. Professor Kratz pointed out that the data contained therein are of great help to the engineers in selecting and checking design conditions for a plant, estimating the effect on comfort of varying rates of air change, intermittent operation, air deliveries, duct system and room temperature gradients.

The second technical paper on the program included information on the effect of vanes in reducing pressure loss in elbows in a 7-in. square ventilating duct. This paper was the result of research sponsored by the ASHVE in cooperation with Lehigh University, and was prepared by M. C. Stuart, C. F. Warner, and W. C. Roberts. Mr. Warner called attention to the fact that the data reported in this paper show reduction of pressure loss in elbows by the use of vanes and splitters.

The concluding paper at the first technical session was on the trend curves for estimating performance of panel heating systems and was presented by Professor F. W. Hutchinson, co-author with Professor B. F. Raber of the University of California. Prof. Hutchinson explained that the ceiling is the most effective location for radiant heating panels, and the performance of such panels becomes more effective as outside temperatures decrease and panel surface temperature, ventilation rate, and structure conductance increase.

At the second technical session Professor Richard C. Jordan, University of Minnesota, gave a paper on the overloading of viscous air filters during accelerated tests, which he and Professor Frank B. Rowley prepared.

In a paper on the air conditioning of blackout plants, presented by W. A. Grant, Philadelphia, it was pointed out that the huge expansion of industrial plants due to the war has introduced air conditioning in more kinds of plants, and in more different processes than ever before. The author stated that the engineering design methods follow well established application practices, and with speed the paramount factor in the armament program, air conditioning has been classed as an essential industry for reducing product rejects, maintaining spoilage to a minimum, and keeping every man and machine at the peak of production efficiency.

W. L. Fleisher, New York, past president of the ASHVE, made a suggestion that a special committee be appointed to study the air conditioning question of blackout plants.

The Committee on Arrangements, Minnesota Chapter of the ASHVE in charge of semi-annual meeting. (Left to right, front row) H. E. Gerrish, A. B. Algren, R. E. Backstrom, R. B. Rowley, J. F. Stafford, and N. D. Adams. (Second row) D. B. Anderson, F. F. Lange, E. F. Bell, M. H. Bjerken, W. McNamara, E. F. Jones, F. W. Legler, and M. S. Wunderlich.

Lt. Comdr. A. R. Behnke, Marine Corps, presented an interesting address on physiologic studies pertaining to Naval ventilation.

At the conclusion of a discussion on this subject, Dr. Charles Sheard, director of the Division of Biophysical Research of Mayo Foundation, presented some further investigations of calorimetric and skin temperature measurements of the extremities and their significance.

D. B. Anderson was the author of a paper on heat loss studies in four identical buildings to determine the effect of insulation, presented at the third session. With the aid of slides and a movie film, Mr. Anderson showed how fuel savings effected by installing various thicknesses of insulation in four identical dwellings of typical construction were determined and compared with calculated results. He stated that inside wall and glass surface temperatures were observed, together with the actual air temperature gradients from the floor to ceiling.

C. O. Wood, with Prof. Gordon B. Wilkes, both of M.I.T., presented a paper on the specific heat of thermal insulating materials. Mr. Wood stressed the point that data have thus far been lacking on this subject and the authors have experimentally determined the specific heat of 15 of the more common insulating materials. The mean specific heats, Mr. Wood brought out, were determined for the temperature range within which the materials are generally used; this range being from 80 to 212F for the organic insulators and from 80 to 1350F for the higher temperature materials. He concluded the paper with a discussion of the importance of heat capacity.

The final paper at the third technical session was on the simultaneous heat and vapor transfer characteristics of an insulating material and was written by F. G. Hechler, E. R. McLaughlin and E. R. Queer, The Pennsylvania State College. In the absence of the authors this paper was presented by John James, New York, N. Y., technical secretary of the ASHVE, who outlined the two major forces which influence the transfer of vapor through building insulations, and described the two types of moisture movement and the results of investigations and the operation of the test equipment used for determining moisture and vapor conditions. Mr. James also pointed out that the paper demonstrates that moisture can collect in or be driven from specimens under test and that the conductivity is not appreciably affected by the first 7% moisture.

FUEL STORAGE AND HEATING VALUE DATA

Table 1 shows the space required per ton of bituminous, semi-bituminous, and anthracite coals of different origin and sizes. Table 2 gives similar information for wood and miscellaneous solid fuels, while Tables 3 and 4 cover oil and other liquid fuels.

The storage space required for a season's operation of a heating plant, not including service hot water, for installations in most parts of the United States[1] can be determined by the formula

$$T = \frac{H \times D}{(70 - t_o) \times E \times F_c \times 67} \text{ for coal}$$

$$G = \frac{30 \times H \times D}{(70 - t_o) \times E \times F_o} \text{ for oil}$$

$$M = \frac{H \times D}{(70 - t_o) \times E \times F_g \times 33} \text{ for gas}$$

where

T = seasonal coal consumption for heating for a normal year, exclusive of service hot water, in tons of 2000 lb,
G = seasonal oil consumption in gallons, heating only,
M = seasonal gas consumption in thousand cubic feet, heating only,

TABLE 1. STORAGE SPACE REQUIRED FOR AND HEAT CONTENTS OF VARIOUS COALS

Source and Size	Space Required, Cu. Ft. per Short Ton	Space Required, Cu. Ft. per Long Ton	Heat Value, B.t.u. per Lb.†
BITUMINOUS COAL			
Alabama domestic	44.0	49.3	11,700 to 14,200
Alabama run-of-mine	37.1 to 39.3	41.5 to 44.0	
Arkansas run-of-mine	33.6 to 40.4	37.6 to 45.2	12,700 to 13,700
Colorado lump	38.1 to 39.6	42.6 to 44.4	10,000 to 13,500
Colorado domestic	40.5	45.4	
Georgia 60% lump, 10% nut, 30% slack	37.1	41.5	12,000 to 14,000
Illinois domestic lump	40.5	45.4	10,300 to 12,200
Illinois run-of-mine	36.1 to 36.8	40.4 to 41.2	
Illinois lump	41.3 to 45.5	46.2 to 50.9	
Iowa 60% lump, 25% nut, 15% slack	43.0	48.1	9,000 to 11,000
Kansas 90% lump, 5% nut	36.1	40.5	10,700 to 12,700
Kentucky 95% lump, 5% nut	36.7 to 46.6	41.0 to 52.1	11,500 to 14,300
Kentucky lump	42.1 to 44.5	47.1 to 49.8	
Montana 90% lump, 5% nut, 5% slack	38.7	43.4	10,500 to 11,500
Ohio 90% lump, 5% nut, 5% slack	40.9	45.8	12,000 to 13,000
Ohio 70% lump, 15% nut, 15% slack	42.1	47.1	
Ohio 60% lump, 30% nut, 10% slack	43.0	48.1	
Ohio 40% lump, 20% nut, 20% slack	40.0	44.8	
Oklahoma 40% lump, 20% nut, 20% slack	40.0	44.8	12,200 to 14,000
Oklahoma 35% lump, 45% nut, 20% slack	41.3	46.2	
Pennsylvania 90% lump, 5% nut, 5% slack	40.4 to 42.6	45.2 to 47.6	11,900 to 14,300
Pennsylvania 70% lump, 20% nut, 10% slack	39.6	44.4	
Pennsylvania 60% lump, 25% nut, 10% slack	39.6	44.4	
Pennsylvania 20% lump, 30% nut, 50% slack	38.5	43.1	
Pennsylvania 10% lump, 15% nut, 75% slack	38.5	43.1	
Pennsylvania 10% nut, 90% slack	37.4 to 40.5	41.8 to 45.4	
Pennsylvania slack	38.5	43.1	
Pennsylvania lump	43.0	48.1	
Utah 90% lump, 5% slack	45.0	50.4	12,000 to 13,000
SEMI-BITUMINOUS COAL			
West Virginia 70% lump, 15% nut, 10% slack	36.1	40.4	13,600 to 14,800
West Virginia 60% lump, 30% nut, 10% slack	42.6	47.6	
West Virginia 20% lump, 10% nut, 70% slack	36.4	40.7	
West Virginia 5% lump, 10% nut, 85% slack	36.1	40.4	
West Virginia 4% lump, 2% nut, 94% slack	37.1	41.5	
West Virginia 3% lump, 5% nut, 92% slack	34.8	39.0	
West Virginia 5% nut, 95% slack	35.4	39.6	
ANTHRACITE			
Pennsylvania egg	34.6 to 37.8	38.8 to 42.3	12,800 to 13,400
Pennsylvania chestnut	35.4 to 38.1	39.6 to 42.6	
Pennsylvania pea	36.8 to 37.4	41.2 to 41.9	
Pennsylvania buckwheat	39.6	44.4	

†High and low values reported from state in question; heat value does not necessarily apply to the density data as tabulated.

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TABLE 2. STORAGE SPACE REQUIRED FOR AND HEAT CONTENTS OF WOODS AND MISCELLANEOUS SOLID FUELS

Name	Space Required, Cu. Ft. per Lb.	Heat Value, B.t.u. per Lb., Dry
WOOD		
Ash	.0337	5400
Beech	.0328	5350
Birch	.0320	5200
Chestnut	.0475	5800
Elm	.0412	6000
Hickory	.0278	5400
Maple, red	.0400	5950
Oak, white	.0298	5550
Pine, white	.0581	5850
Pine, yellow	.0555	9200
Walnut	.0320	4650
MISCELLANEOUS SOLID FUELS		
Coke	.03	12,500 to 15,000
Charcoal	.07 to .10	11,000 to 14,000
Peat	.016 to .14	7,000 to 10,000
Hog fuel	.0256 to .0512	Same as wood
Sawdust	—	from which made
Wet tan bark	—	2,500 to 3,000
Straw	.05	5,450 to 6,750
Bagasse	—	8,000 to 8,700
Lignite	.0185 to .0208	11,000 to 12,500
Sawdust briquettes	.0125 to .0133	8,000 to 8,200
Shelled corn	—	7,800 to 8,500
Cottonseed hulls	.06 to .07	7,000 to 7,200
City garbage	.023 to .025	7,000 to 9,000

TABLE 3. STORAGE SPACE REQUIRED FOR AND HEAT CONTENTS OF FUEL OIL

Oil Standard No.	Space Required, Cu. Ft. per Gal.	Heat Value, B.t.u. per Gallon
1	0.13368	136,000 to 139,000
2		139,500 to 140,500
3		141,000 to 143,500
4		144,000 to 145,500
5		146,000 to 148,500
6		149,000 to 152,000

TABLE 4. STORAGE SPACE REQUIRED FOR AND HEAT CONTENTS OF MISCELLANEOUS LIQUID FUELS

Liquid	Space Required, Cu. Ft. per Lb.	Heat Value, B.t.u. per Lb.
Coal tar	.0128 to .0169	16,000 to 17,300
Benzene[1]	.0181 to .0185	18,170
Ethyl (grain) alcohol	.0202	12,810
Methyl (wood) alcohol	.0203	9,600
Gasoline	.0212 to .0224	20,600
Kerosene	.0197	20,000 to 20,500

[1]Not to be confused with benzine (gasoline).

TABLE 5. ANGLE OF SLIDING FOR COALS

(Table for coal shows angle with horizontal at which coal will slide for coal on bright steel chute. In piles the angle of repose is somewhat higher than the figures below. Slight freezing can increase these angles sharply)

Coal	Angle with Horizontal	
	Sliding Starts	Sliding Continues
BITUMINOUS		
	(Deg., Min.)	(Deg., Min.)
Illinois 6 in. lump	21 50	20 40
Illinois 3 x 6 in. egg	21 00	19 10
Illinois 3 x 2 in. lump	20 30	19 00
Illinois 1¼ x 2 in. nut	20 40	19 20
Illinois ¾ x 1¼ in. nut	21 00	19 40
Illinois slack	25 40	22 30
Oklahoma screenings	24 00	22 30
Oklahoma chestnut	21 00	19 00
Kentucky egg	21 50	20 20
ANTHRACITE		
	(Deg., Min.)	(Deg., Min.)
Pennsylvania egg	15 40	14 00
Pennsylvania chestnut	16 40	15 10

COKE

(Sliding angles below are for coke on coke, not on chutes. High values are for dry coke, lower values for wet coke)

Size	Sliding Angle	Angle of Repose
	(Degrees)	(Degrees)
Furnace	43 to 45	45 to 47
Stove	39 to 41	43 to 44
Breeze	37 to 40	41 to 44

H = estimated hourly heat loss under design (coldest) conditions[2],

D = normal seasonal total of degree days for locality in question,

t_o = outside design temperature for locality in question,

E = overall efficiency of heating plant, expressed as a decimal, and

F_c = heating value of coal used, per pound.

F_o = heating value of oil used, per gallon,

F_g = heating value of gas used, per cubic foot.

To the quantity of fuel obtained from the above should be added the fuel required for service hot water. This can be estimated from such data as that given in H & V's Reference Data 41-42.

[1]Except the deep South, the three most Northern central states, and the Pacific Coast. For these sections, see Degree-Day Handbook.

[2]If H is not available multiply the square feet of installed equivalent steam radiation by 240 and use the product instead of H.

Published by Heating and Ventilating, *148 Lafayette St., New York* 8/42

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REVIEWS of TECHNICAL publications

STRENGTH OF SOLDERED JOINTS

"Building Materials and Structures—Report BMS83," by A. R. Maupin and W. H. Swanger. Available from the Superintendent of Documents, Washington, D. C. Price, 10 cents

The National Bureau of Standards of the U. S. Department of Commerce has just completed an investigation dealing with the strength of sleeve joints in copper tubing made with various lead-base solders. Solders of the following types were used: lead-silver, lead-tin-antimony, lead-cadmium, high lead-low tin, and high purity lead. Tensile tests at room temperature (short-time tests) were made, together with long-time tests at temperatures ranging from 85F to 325F.

The results of this investigation show that joints in copper tubing made with lead-base tin-free solders can be used safely at temperatures up to 325F.

This study supplements a previous investigation outlined in report BMS58 which dealt with joints made with two tin-base solders. Due to the change in the world's metal situation in the last few months, especially in regard to access to the tin supply, this latest bulletin is of timely interest.

Paper covered, 8 x 10 in., 12 pages.

HEAT TRANSMISSION

"Heat Transmission," by W. H. McAdams. Second edition. Published by McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York, N.Y. Price, $4.50.

In the ten years since the appearance of the original edition of this book, numerous and extensive developments in the transmission of heat have occurred. Most of the literature dealing with these developments has, however, been scattered through miscellaneous forms of publications, and for that reason is largely unavailable to students, practicing engineers, and other users. In this newly revised and enlarged edition, the author, who is professor of chemical engineering at the Massachusetts Institute of Technology, has as his purpose the remedying of this situation by gathering and clarifying this material and coordinating the new with the old. Some of the correlations based on the new data deal with the flow of fluids in tubes for the streamline and transition regions, streamline and turbulent flow in annuli, flow parallel to planes, gravity flow of liquids in layer form, flow across banks of tubes, flow past finned surfaces, turbulent flow past spheres, and natural convection from planes. The author in most cases indicates sources for the supporting data with comments as to their dependability.

Graphical methods are used freely to correlate data and to organize them into a form readily usable by the design engineer. Many of the developments which have given a new insight into the mechanism of heat transfer have had a photographic basis. For instance, shadow photography and the use of the interferometer have added considerably to the knowledge of natural convection in gases. Other photographic investigation has likewise brought about a clear understanding of such phenomena as film-type and dropwise condensation of vapors, nuclear and film boiling of liquids outside tubes, and dry-wall vapor binding due to spray formation with liquids boiling inside tubes.

The solution of many illustrative cases lends clearness to the next, and a large number of practical problems is furnished in order to test the reader's grasp of principles and methods.

Chapter headings are as follows: Conduction; Heating and Cooling of Solids; Radiant Heat Transmission; Dimensional Analysis; Flow of Fluids; Introduction to Heat Transfer between Fluids and Solids; Heating and Cooling Fluids Inside Tubes; Condensing Vapors; Heat Transfer to Boiling Liquids; and, Application of Design.

The book is well indexed and has an appendix containing unusual information on the field covered by the book.

Cloth-bound, 459 pages, 6 by 9 inches.

INDUSTRIAL HEALTH

"Manual on Industrial Health for Defense." Issued and available from the Division of Health and Social Services, 18 Tremont St., Boston, Mass.

The problem of industrial health is increasing in importance daily as the nation swings into its full stride in war production. This intensified rate of production requires an ample supply of trained workers, both men and women, who are physically and mentally capable of carrying on the job.

In order to provide an outline of the fundamental requirements and standards for essential industrial health services, the Committee on Public Safety has prepared a manual which is intended to serve as a guide. Its purpose is to assist local industrial hygiene committees organized under the local health committees to develop their industrial health programs.

Twenty-five thousand copies of this paper covered, 5¼ in. by 7½ in. 30-page booklet have been prepared for free distribution.

MOTOR MAINTENANCE

"Motors, Their Selection and Maintenance," by O. F. Vea. Published by The Industrial Press, 148 Lafayette Street, New York, N. Y., from Heating and Ventilating, August, 1942. Price, 25 cents.

An eight-page, 8¾ by 11⅝ pamphlet printed in green which constitutes HEATING AND VENTILATING's Reference Section No. 6, gives detailed information on the best methods for keeping electric motors in good operating condition. Phases covered are Selection and Installation; Inspection Schedules; Lubrication; Care of Insulation; and Cleaning and Overhauling. Special recommendations are given for direct current motors. Tables showing the various characteristics and typical applications for all ordinary types of motors are included.

SMOKE PREVENTION

Proceedings of the 36th Annual Convention, Smoke Prevention Association of America, Inc., 139 N. Clark Street, Chicago, Ill. Price, $1.00.

This 135-page, 8½ x 11 in. mimeographed paper covered book gives the complete proceedings of the Association's meeting at Cleveland, June 2-5, 1942.

Among the many papers that deal with the smoke abatement problem were the following: Report on Dust Fall Survey in Cleveland, Ohio, Over Four-Year Period, A. E. Hutchinson; A study of Atmospheric Pollution, W. F. Davidson; Chimney Performance and Its Relation to the Smoke Problem, J. G. Mingle; Abatement of Nuisance Caused by Discharge of Metallic Oxides from Non-Ferrous Secondary Metal Smelting Plants, E. G. Dolezal; and, Influence on Atmospheric Pollution of the Exhausts from Diesel Automotive Vehicles and Locomotives, R. J. Bender.

FUEL INVESTIGATION

"Correlation of Domestic Stoker Combustion with Laboratory Tests and Types of Fuels," by L. C. McCabe, S. Konzo, and O. W. Rees. Printed by the Engineering Experiment Station, University of Illinois, Urbana, Ill.

This 20-page, 7x10 inch report covers a continuation through 1939 and 1940 of work begun in 1937 by the Illinois Geological Survey, wherein exploratory stoker tests of coals from Franklin County, Illinois were made. In the early tests it had been demonstrated that concentration of vitrain in these coals causes excessive swelling and coke-tree formation, whereas clarain is more free-burning and has less tendency to form coke-trees. Tests short of actual combustion in stoker installations that would properly diagnose different types of coals and foretell their behavior in stoker use have been desired, and the tests described in the present report were intended to so correlate indicated properties with actual performance. The tests substantiate earlier findings in regard to the importance of physical composition of coal as related to combustion behavior, meaning in particular its coke-forming properties.

No correlations between agglutinating value and Agde Damm plasticity tests and coke formation were apparent. A certain correlation was noted, however, between British Standards Swelling Index values and coke formation in the stoker fire.

Laboratory tests described in this report measure more or less specific characteristics of coal. On the other hand, behavior of coal in an underfeed stoker is influenced simultaneously by many physical and chemical properties. The influence of certain properties may mask that of others. Studies are now in progress at the University to clarify some of these relationships.

WELDING

"Welding Handbook". Published by the American Welding Society, 33 W. 39th Street, New York. N. Y. Price, $6.00.

With increasing use of welding as an important production tool in the construction of ships, tanks, planes, and other war equipment, there is an urgent need for an authoritative, impartial, and concisely written handbook. The purpose of this book is to fulfill such a need. In order to meet these qualifications, the Committee responsible for its preparation selected some 270 leading welding experts, authorities in their particular fields, as members of committees preparing the respective chapters.

The general style of the volume is that of a handbook designed to give engineers a convenient reference book on the technical phases of welding. The logical order in which the material is placed, however, makes the work suitable for use as a textbook in engineering schools, or as a reference book in trade schools.

The book is subdivided into a number of general groups, as follows: (1) The physics of metallurgy of welding and the weldability of steels; (2) the welding and allied processes; (3) the materials used; (4) training, inspection and safety; (5) design and testing of welds, and (6) applications.

Fabricoid cover, 6 by 9 in., 1593 pages.

SPECTRUM CHART

"The Entire Electromagnetic Spectrum," compiled by Westinghouse Research Laboratories, East Pittsburgh, Pa. Price, $2.00.

A new seven-color wall chart approximately 30 by 40 in. in size, compiled by the company's research laboratories, shows the entire electromagnetic spectrum. Spectral terms are defined in a special glossary printed on the chart, and typical uses and applications are listed for the various bands of radiation. Should be of interest to teachers of physics, chemistry, and electrical engineering and to practicing engineers and scientists.

Chart may be obtained from Publications Section, 6-N-17, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

(Continued on page 62)

Tube-Turn Welding Fittings are built to *stand the gaff* at the turns!

FASTER INSTALLATION WITH TUBE-TURN WELDING FITTINGS

In the above assembly, Tube-Turn welding fittings are speeding up the erection schedule and permitting a compactness of piping impossible if handled any other way. Also, their uniform wall thickness makes aligning and welding quicker and easier. Note the five Tube-Turn fittings in this small piping section: (1) a 90° elbow; (2) a tee; (3) another 90° elbow; (4) a lap joint welding nipple; (5) a lap joint flange.

It's tough enough to hang on the board when a speed boat is making sharp turns along a zig-zag course, but add the perilous sport of water jousting—and the *danger at the turns* is doubled!

Extra punishment occurs *at the turns* in industrial piping systems, too. That's why it is safer practice to *weld piping with Tube-Turn fittings.* Tube-Turn fittings provide maximum strength, prevent leakage permanently, and practically eliminate maintenance costs.

There's a Tube-Turn fitting for *every* pipe welding need—the right type, size and weight for every job. Insist on genuine Tube-Turn welding fittings for longer life in your piping.

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TUBE TURNS, INC., LOUISVILLE, KY. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Tulsa, Houston, Los Angeles, Washington, D. C. *Distributors in all principal cities.*

TUBE-TURN TRADE MARK — The FIRST WELDING FITTINGS 1ST AND STILL THE BEST — *Welding Fittings*

TRADE ASSOCIATIONS DIRECTORY

"Trade and Professional Associations of the United States". Published by the U.S. Government Printing Office. For sale, Superintendent of Documents, Washington, D.C. Price, 70 cents.

This 320-page paper covered volume, prepared by the U. S. Department of Commerce, size 9 x 11½ in., lists some 3100 National and Interstate Associations available for national mobilization activities in 1942.

As war work has progressed, such a directory has become more and more necessary in order to facilitate cooperation among the many trade associations and professional organizations of the country. These groups have a gross membership of over 40 million persons.

The author, who is chief of Trade Associations Section, Department of Commerce, has included much other factual material for each of the 48 States, such as number of factories, retail stores, farms, and service establishments.

Basic data are presented on such national groups as trade associations, professional, consumer, and farmer organizations, patriotic societies, and labor unions.

BUILDING CONSTRUCTION

"Field Inspectors' Check List for Building Construction." For sale, Superintendent of Documents, Washington, D. C. Price, 20 cents.

This 68-page, paper-cover, 5 x 7½ in. booklet was prepared by a representative committee of Federal Agencies engaged in activities relating to the design and erection of buildings and is intended as an authoritative guide for field inspectors in checking materials and workmanship in building construction. The book is intended purely as a daily reminder of items which an inspector should follow in detail so as to make sure that no important step is overlooked as construction progresses. It is in no sense an outline of specifications. Due to its conciseness and to the logical order in which construction procedures and interlocking operations follow each other, this book should be especially useful to those engaged in this work.

ADVERTISING REGULATIONS

"Reference to the Army and Navy in Advertising." National Better Business Bureau, Inc., 405 Lexington Ave., New York, N. Y. Price, 10 cents

Under date of June 10, 1942, the Bureau has issued a new revision of its bulletin regarding reference to the Army and Navy in advertising. The revised bulletin defines the War Department's latest policy with reference to (1) the use of photographs of Army personnel in advertising; (2) the use of civilian models in Army uniforms for advertising purposes; (3) the use of Army insignia in advertising, and (4) reference to the WAAC in advertising.

Eight mimeographed pages, 8½ by 11 inches.

REFRIGERATION STANDARDS

"Proposed Commercial Standard for Commercial Electric Refrigeration Condensing Units." Published by U. S. Department of Commerce, National Bureau of Standards, Washington, D. C.

Adopted by the Manufacturers' Conference of June 23, 1942, this commercial standard is intended to establish minimum standard specifications and methods of test for commercial electrical refrigeration condensing units, for the guidance of manufacturers, distributors, installers, contractors, and users.

Its scope covers requirements, rating, motor loading, and testing of air-cooled and water-cooled, belt driven commercial electric refrigeration condensing units in 1/5 to 3 hp sizes, and water-cooled units of 5 hp, using methyl chloride, Freon 12, or SO_2 refrigerants.

For purposes of field selection machines are divided into three groups as follows: —25F to 0F, 0F to + 25F and +25F to +45F.

WELDING STANDARDS

"Standard Methods for Mechanical Testing of Welds." "Definitions of Welding Terms." Published by the American Welding Society, 33 West 39th St., New York. Price, 40 cents each.

These two bulletins together set forth the latest approved standards covering the field of welding. The bulletin on testing of welds consists of 25 pages of illustrated text, describing in detail the principal mechanical tests applied to welds, including those for density, soundness, tensile strength, shearing strength, and ductility. A section on etching reagents and procedures for etching is included.

The booklet on definitions has 32 pages, consisting of a glossary of terms defining welding materials and processes. Sketches are used to explain terms, and a master chart shows the various subdivisions of the principal welding processes.

TESTS FOR FAN NOISES

"Sound Measurement Test Code for Centrifugal and Axial Fans." Published by the National Association of Fan Manufacturers, 5-208 General Motors Bldg., Detroit, Michigan. Price, 10 cents.

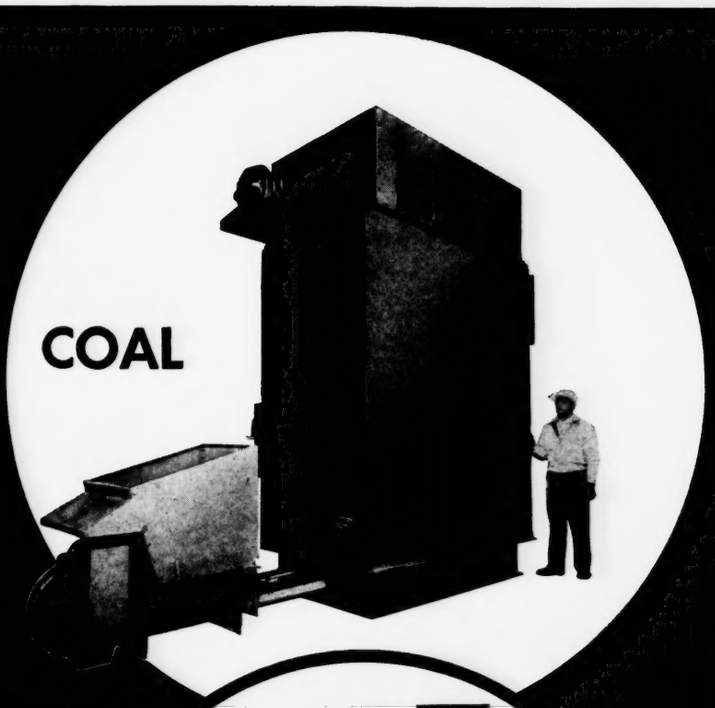
Prepared by the engineering committee of NAFM, this 8-page, 8½ x 11 in. bulletin is designed to provide a standard method of measuring sound in fans and blowers, with specific reference to air conditioning, heating, ventilating, and general air handling problems.

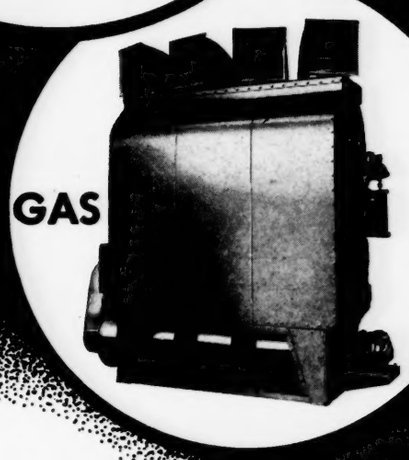
Incorporated are standards previously adopted or tentatively accepted by such bodies as the American Standards Association and the U. S. Navy.

The prescribed methods for setting up test instruments and making observations are shown in line diagrams and explained in the text.

DRAVO DIRECT FIRED HEATERS

. . . SAVE TRANSPORTATION & CRITICAL MATERIALS





● By actual comparison, made for the information of men responsible for allocating vital materials—heating systems of Dravo self-fired units use less metal* in the making and fewer man-hours in installing than heating plants of conventional design.

In operation, fuel requirements are 20 to 25% lower—a desirable cash economy in peace time, but important today as a means of conserving fuel and its transportation.

The Direct-Fired method of producing heat is not new—Dravo sold and installed such systems a decade ago. Today production and sales are soaring because of the demands of the War Program—but orders for quick delivery of standard sizes for essential plants can still be taken.

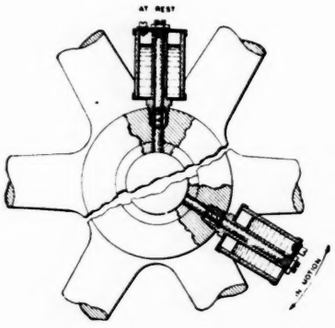
Architects, consultants, heating engineers, plant owners, purchasing agents,—anyone with an interest in the heating problem of a war plant—write or wire for description of the line of DRAVO HEATERS. Our engineering department will submit detailed recommendations, prices, weights, estimated fuel consumption, and delivery schedules for comparison with similar data on any other heating system you may have under consideration.

DRAVO CORPORATION
HEATER DEPARTMENT
DRAVO BUILDING PITTSBURGH, PA.
Sales Offices in Principal Cities

*** WHY DRAVO HEATERS HAVE EARNED HIGHEST PRIORITY**

● Just off the press, 12 page booklet showing the savings in critical materials made possible through the use of Dravo Heaters. Copy on request.

NEW EQUIPMENT



Loose Pulley Oiler

NAME—Oil-Rite loose pulley lubricator.

PURPOSE—For continuous lubrication of loose pulleys, idler pulleys, clutches, eccentrics, and similar rotating parts.

FEATURES—Consists of a simple glass oil reservoir through which a hollow metal stem passes, the extended portion of the stem acting as a mounting device. Two small holes in the stem near the top of the glass reservoir admit oil into the stem during rotation, the oil being thrown to the top of the chamber by centrifugal force. A cylindrical felt wick inside the stem extending through the pulley hub and resting directly on the shaft conveys oil by capillary action to the shaft. A compression spring holds the wick firmly against the shaft during rotation. Oil feed through the wick is regulated by means of a small plug which controls the area of the two oil ports in the stem.

SIZES AVAILABLE—Five standard sizes, in capacities from ¼ to 2½ oz. for standard tappings from ⅛ to ¼ in.

MADE BY—*Oil-Rite Corporation, 3466 S. 13th St., Milwaukee, Wisconsin.*

Evaporative Condensers

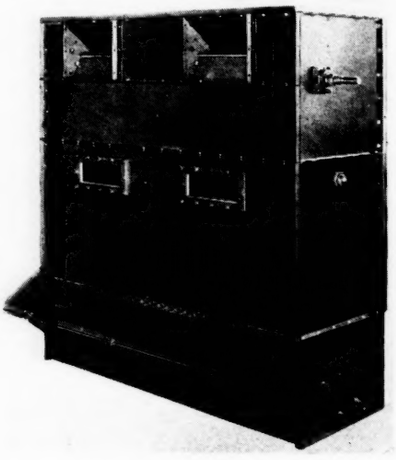
NAME—Type EVS Aquamisers.

PURPOSE—For use with Freon refrigeration compressors and for process liquid cooling.

FEATURES—Consists of a three-part fabricated sheet metal casing having fan and condenser chambers and a water sump. Individual sections are of sizes and weight to permit easy handling and erection. Casing made of heavy galvanized steel with all parts protected against corrosion. The temperatures to which liquid can be cooled for these units depend upon wet bulb temperature of the air, the kind of liquid, and the entering temperature of the air.

SIZES AND CAPACITIES—Complete range of sizes from 5 to 100 tons normal refrigeration.

MADE BY—*Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.*



Portable Electric Shears

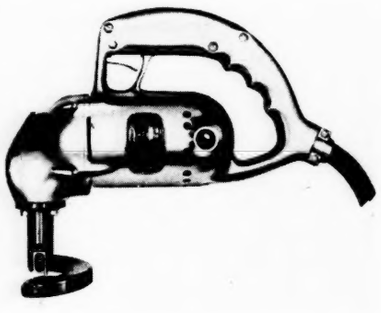
NAME—Improved Lectro-Shears.

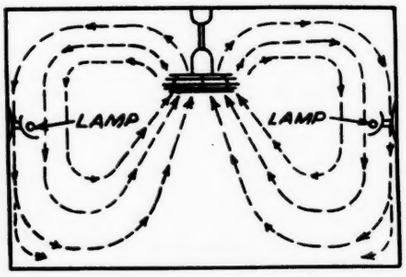
PURPOSE—For cutting sheet metal.

FEATURES—Both the 16 ga. and 18 ga. Lectro-Shears have been redesigned by the company in order to improve their ease of handling and operating characteristics. The No. 16 shear (illustrated) has been equipped with a new operating handle which gives the tool better balance and control on curved and irregular lines. It is equipped with an instant release trigger switch with locking pin for continuous operation. Handle is so shaped that it can be used over the tool or at the rear end. The No. 18 shear also has been changed to improve its appearance and handling properties.

SIZES—Same as in previous models, No. 18 handling up to 18 ga. steel and No. 16 up to 16 ga.

MADE BY—*Black & Decker Manufacturing Company, Towson, Maryland.*





Air Circulator

NAME—Reco Radi-Aire circulator.

PURPOSE—To increase the germicidal effectiveness of ultra violet ray lamps by eliminating dead air pockets.

FEATURES—Consists of an axial flow fan so mounted in a room as to discharge air vertically upward toward the ceiling Resulting air movement is outward horizontally under the ceiling to the walls, thence downward to the floor, back to the center of the room, then up again to the fan. This assures complete movement of the air in all parts of the room and brings all of the air within effective range of the rays of the lamp. The circulator can also be used to distribute germicidal vapors evenly throughout a room.

SIZES AVAILABLE—Comes in 20 in. and 24 in. diameter propellers in either ceiling, low stand, or high stand models. In three speeds, 110 volt, 60 cycle a.c. current.

MADE BY—*Reynolds Electric Company, 2650 W. Congress St., Chicago, Ill.*

Domestic Heating Boiler

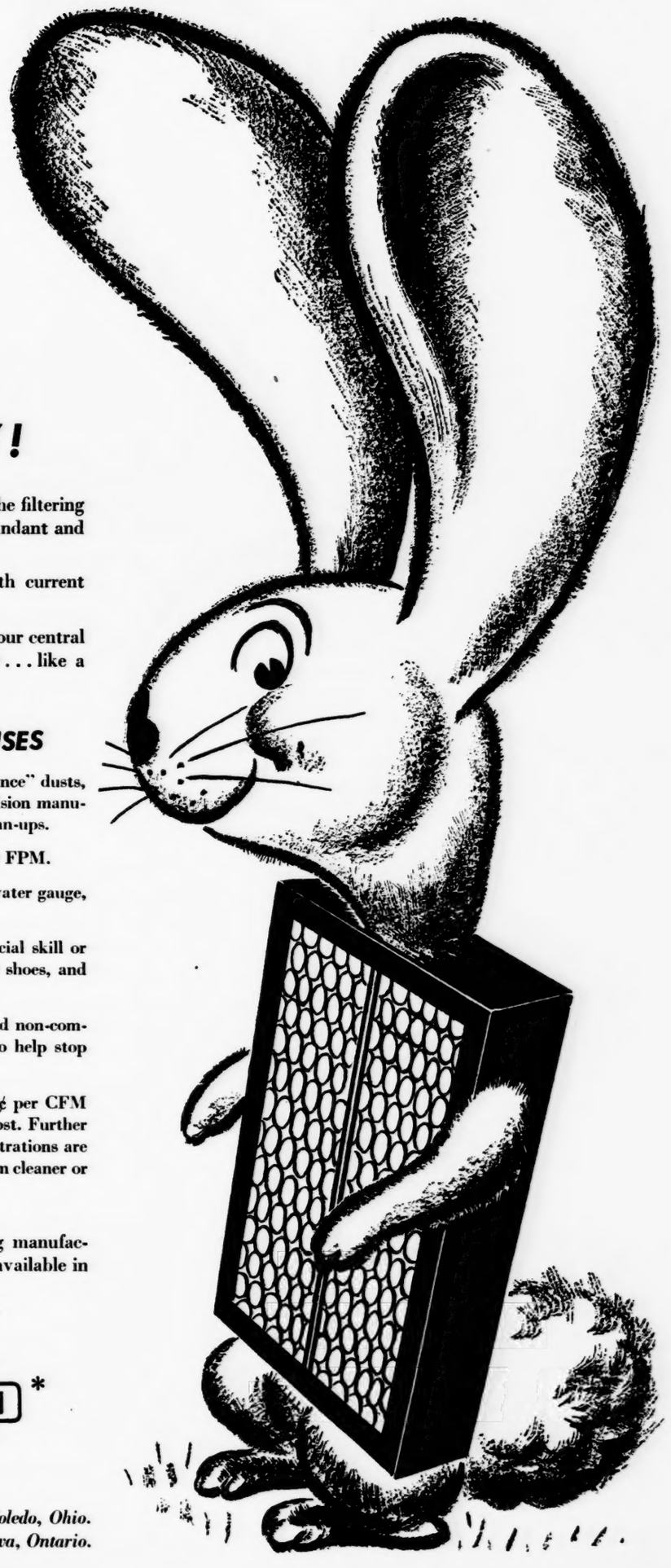
NAME—Arcoliner.

PURPOSE—For use in small and medium size heating applications such as found in war housing.

FEATURES—Manufacturer presents this as a new light-weight cast iron heating boiler with effective direct heating surface, efficient combustion space, two-pass finned flue surfaces and large steam space. The boiler is a universal type, burning either coal (hand-fired or stoker) or oil, with easy convertibility from one to the other. Provision is made for built-in indirect water heater.

SIZES AVAILABLE—Comes in four sizes rated at 180 to 460 sq ft installed radiation for steam, and 290 to 740 sq ft for hot water, based on coal firing.

MADE BY—*American Radiator & Standard Sanitary Corp., Box 1226, Pittsburgh, Pa.*



YOU GET 'EM QUICK... LIKE A BUNNY!

DUST-STOP* AIR FILTERS are 100% American. The filtering medium is made from materials which are abundant and easily available in this country.

And Dust-Stop production is keeping pace with current demands.

The next time you are placing a filter order for your central system, remember that you get Dust-Stops *quick* . . . like a bunny. *Beside*:...

YOU GET 6 OTHER BIG PLUSES

EFFICIENCY: Dust-Stops remove virtually all "nuisance" dusts, even hay-fever pollen. They help precision manufacture. Reduce lost time for plant clean-ups.

CAPACITY: 2 CFM per square inch of area at 300 FPM.

RESISTANCE: Average resistance, new, in inches of water gauge, .062 for 1-inch and .13 for 2-inch.

EASY TO CHANGE: Replacing Dust-Stops requires no special skill or tools; it's as simple as changing your shoes, and quicker, too!

FIRE-SAFETY: Dust-Stop's glass filtering material and non-combustible adhesive have been known to help stop the spread of fire.

ECONOMICAL: 1¢ per CFM to install, less than 1/10¢ per CFM to replace . . . that's all Dust-Stops cost. Further savings are possible, when dust concentrations are heavy, by cleaning them with a vacuum cleaner or by gently rapping out.

• ORDER DUST-STOPS from your air-conditioning manufacturer, jobber, dealer. Or write us. Standard sizes available in No. 1 (1-inch thick), No. 2 (2-inches thick).

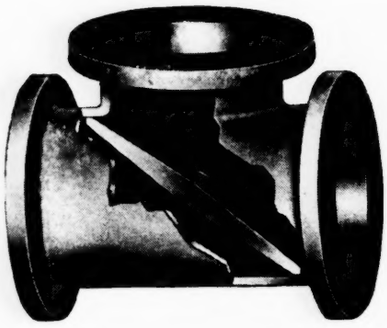
FIBERGLAS*

DUSTOP*

* T.M.Reg. U.S. Pat. Off.

AIR FILTERS

Made by Owens-Corning Fiberglas Corporation, Toledo, Ohio. In Canada, write to Fiberglas Canada, Ltd., Oshawa, Ontario.

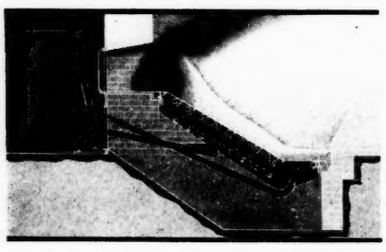


Three-Way Butterfly Valve

NAME—Three-way butterfly valve.
PURPOSE—For mixing and quick interchange service.
FEATURES—Has a self-cleaning, double beveled, streamlined vane which seats wedge-tight against the body of the valve and is said to produce a tight shut-off as well as positive control of volume and pressure. Valve body is constructed of cast steel or cast iron, or can be furnished in special alloys for extra resistance against heat, abrasion and corrosion. Can be adapted to fully automatic control by means of an air diaphragm motor or hydraulic cylinder. In inaccessible locations, a reach rod with de-clutching unit is provided for automatic operation or manual control in case of power failure.
SIZES AND CAPACITIES — For pressures up to 600 lb per sq in.
MADE BY—*R-S Products Corporation, Wayne Junction, Philadelphia.*

Hand Operated Stoker

NAME—Self-cleaning hand operated stoker.
PURPOSE—For converting oil fired boilers to coal.
FEATURES—Consists of a series of rocking grate bars sloping from the level of the fire door opening downward toward the back of the combustion chamber. Coal is piled at the top of the incline from which point it feeds downward towards the bottom of the grate. The feed action is progressive and is secured by occasional manipulation of an external lever connected to a bar linking the grate sections together. A second lever operates a horizontal dump plate located at the base of the inclined grate and by this means the accumulated ashes can be dumped into the pit. Said to be suitable for burning any grade of coal efficiently. Operates on natural draft, no motors required.
SIZES—Capacities up to 4000 lb of coal per hour.
MADE BY—*American Coal Burner Company, 24-18 E. Erie Street, Chicago, Ill.*

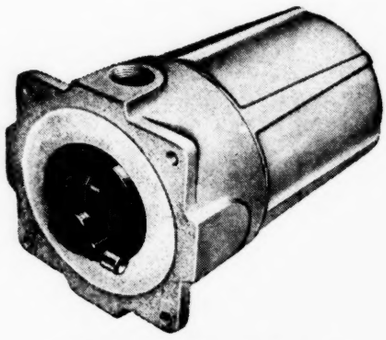


Atmospheric Cooling Tower

NAME—QUAD atmospheric engine jacket water cooler and vapor condensing tower.
PURPOSE—For water, oil, or gas cooling or for steam condensing.
FEATURES—Consists of a four-sided assembly whose sides are made up of the company's typical fin-type heat transfer surface. A large size, slow speed, propeller type fan is mounted horizontally above the cooler drawing air through the heat transfer elements and discharging it upward through a discharge stack. The four-sided design is said to eliminate the serious defects caused by cross-wind currents in the usual arrangement. Horsepower expenditure is less than 25 hp at full maximum cooling and a fraction of this under normal conditions where, by using a two-speed motor, the fan speed can be reduced by 50%. Complete automatic regulation can be provided by using automatic regulating control switch on multiple cooler installations combined with the use of two-speed motors. Designed for easy construction in the field, the four sides being completely self-contained sub-assemblies, shipped to destination.
SIZES AND CAPACITIES—Coolers in capacities up to 74,300 Btu per min for water or 22,000 Btu per min for oil. Steam condensing units up to 15,600 lb condensate per hr.
MADE BY—*Young Radiator Company, Racine, Wisconsin.*

Pipe Size Selector

NAME—Pipe selector for steam.
PURPOSE — For calculating steam pipe sizes.
FEATURES—A circular slide rule type of computer consisting of a 7¼ in. paper disc mounted on a similar disc 9 in. in diameter. Steam pipe sizes for pressure drops per 100 lineal ft of 1, 3 and 5 lb can be computed.
PRICE—35 cents each, available from manufacturer.
MADE BY—*E. S. Atkinson Company, 1115 Sassafras Street, Erie, Pa.*

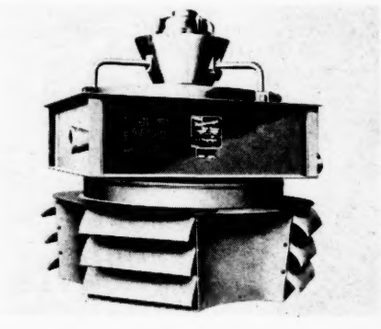


Explosion Proof Timer

NAME—Type TD1C explosion proof time delay relay.
PURPOSE—For safe control of time cycles in explosive atmospheres.
FEATURES—Freedom from the danger of explosions in atmospheres containing gasoline, naphtha, petroleum, benzol, acetone, lacquer solvents, and natural gas, is claimed for this device. The type illustrated is arranged for panel board mounting with setting knob and dial projecting. Remote control with momentary start button can be obtained by the use of an alternate model TD1 with a small relay, the same control housing being employed as with type TD1C.
MADE BY—*R. W. Cramer Company, Centerbrook, Conn.*

Variable Discharge Unit Heater

NAME—Revolving unit heater with variable volume discharge outlet.
PURPOSE—To provide uniform heat distribution in long rectangular shaped spaces.
FEATURES—Has inbuilt provision for adjusting the amount of heated air discharged from any side of the heater, thus making possible the heating of a long narrow room or building with one revolving unit heater. Air streams are reduced and extended as the discharge outlets cover the sides and ends respectively. The result produced is said to be especially effective in buildings with rooms having low ceilings.
MADE BY—*L. J. Wing Mfg. Company, 160 West 14th Street, New York, N. Y.*



STEEL SCRAP *needed NOW*

TO KEEP WAR MATERIALS MOVING

Iron and steel scrap is used in enormous quantities in making new steel. The steel industry is now in urgent need of scrap to keep the mills operating—to keep war materials moving steadily to American fighting forces and to our Allies.

It is of vital importance to everyone to see that all iron and steel scrap is salvaged now and sent on its way to the mills. Your contribution—much or little—is needed to help swell the total to the necessary volume.

This appeal is not for ourselves alone. Much of the scrap you contribute will be allocated by the Government to be used wherever needed most.

Salvage Anything Made of Iron or Steel

Anything of iron or steel is valuable as scrap—obsolete machinery, worn-out equipment, discarded metal of all kinds. Every manufacturer, businessman, farmer or householder can help to relieve the present scrap shortage by combing his premises for such materials and getting them on their way to the steel mills.

Time is short. The need is urgent. Put your scrap to work for your country—*now!*

WHAT TO DO WITH IT

To get your scrap on its way to the steel mills, sell it to a junk dealer, or get in touch with your local Industrial Salvage Committee. Many organizations have appointed someone to be in charge of salvage—someone who has authority to order the scrapping of material not in actual use, or material which will go out of use in the near future. In this way, available scrap can be located and disposed of most efficiently.

BETHLEHEM STEEL COMPANY

Number of Degree-Days for June, 1942

City	Deg.-Days June, 1942	Deg.-Days June, 1941	Degree-Days Season 1941-42 Sept. 1-June 30
Albany, N. Y.	43	44	6417
Alpena, Mich.	132	96	7306
Anaconda, Mont.*	637	434	8398
Atlanta, Ga.	0	0	2920
Atlantic City, N. J.	17	32	4454
Baker, Ore.	305	192	7341
Baltimore, Md.	4	8	3806
Binghamton, N. Y.	41	53	6035
Birmingham, Ala.	0	0	2591
Bismarck, N. D.	132	105	8094
Boise, Idaho	149	122	6288
Boston, Mass.	61	61	5449
Bozeman, Mont.*	567	380	8706
Buffalo, N. Y.	56	69	6342
Burlington, Iowa	35	—	4516
Burlington, Vt.	77	68	7351
Butte, Mont.*	643	443	9179
Cairo, Ill.	5	0	3738
Canton, N. Y.	65	66	7539
Charles City, Iowa	64	49	6754
Charlotte, N. C.	0	0	2879
Chattanooga, Tenn.	0	0	3513
Cheyenne, Wyo.	193	189	7631
Chicago, Ill.	47	55	5594
Cincinnati, Ohio	13	4	4568
Cleveland, Ohio	25	24	5399
Columbia, Mo.	26	10	4521
Columbus, Ohio	17	8	4929
Concord, N. H.	86	104	6973
Concordia, Kan.	25	10	5137
Davenport, Iowa	31	19	5557
Dayton, Ohio	20	13	4948
Denver, Colo.	65	98	5998
Des Moines, Iowa	30	28	5767
Detroit, Mich.	35	33	5844
Dodge City, Kan.	20	17	4848
Dubuque, Iowa	42	32	5963
Duluth, Minn.	259	222	8488
Eastport, Me.	299	321	7797
Elkins, W. Va.	34	33	5316
El Paso, Tex.	0	0	2390
Erie, Pa.	39	52	5651
Escanaba, Mich.	149	119	7697
Evansville, Ind.	9	5	4426
Fort Smith, Ark.	0	0	3131
Fort Wayne, Ind.	34	32	5861
Fort Worth, Tex.	0	0	2386
Grand Rapids, Mich.	30	30	5843
Green Bay, Wis.	76	71	6898
Greensboro, N. C.	0	3	3683
Harrisburg, Pa.	9	19	4845
Hartford, Conn.	34	45	5696
Helena, Mont.	272	139	8745
Huron, S. D.	57	74	7010
Indianapolis, Ind.	15	7	4810
Ithaca, N. Y.	54	55	6204
Kansas City, Mo.	22	5	4490
Kewanee, Ill.	7	3	5054
Knoxville, Tenn.	0	0	3536
La Crosse, Wis.	49	49	6468
Lander, Wyo.	156	141	8551
Lansing, Mich.	60	45	6310
Lewiston, Me.	93	104	7303
Lincoln, Neb.	22	27	5556
Little Rock, Ark.	0	0	3012
Livingston, Mont.*	541	319	7556
Los Angeles, Calif.	13	14	1341
Louisville, Ky.	6	1	4100
Lynchburg, Va.	0	11	3547
Madison, Wis.	64	60	6548
Marquette, Mich.	202	201	7620
Memphis, Tenn.	1	0	3261
Milwaukee, Wis.	105	92	6644
Minneapolis, Minn.	56	65	6903
Nantucket, Mass.	85	124	5509
Nashville, Tenn.	0	0	3454
New Haven, Conn.	32	45	5262
New Orleans, La.	0	0	1350
New York, N. Y.	24	33	4727
Nome, Alaska*	947	901	11,194
Norfolk, Va.	0	4	3010
Northfield, Vt.	120	130	7828
North Platte, Neb.	50	60	6166
Oklahoma City, Okla.	3	0	3405
Omaha, Neb.	20	27	5814
Oswego, N. Y.	88	70	6494
Parkersburg, W. Va.	4	6	4577
Peoria, Ill.	34	4	5374
Philadelphia, Pa.	13	21	4309
Pittsburgh, Pa.	7	7	4785
Pocatello, Idaho	147	147	7863
Portland, Me.	122	139	7128
Portland, Ore.	126	78	4201
Providence, R. I.	47	46	5351
Pueblo, Colo.	34	53	5822
Raleigh, N. C.	0	2	3024
Reading, Pa.	7	24	4727
Reno, Nev.	116	119	5950
Richmond, Va.	0	8	3535
Rochester, N. Y.	40	42	6344
Roseburg, Ore.	133	105	4156
St. Joseph, Mo.	25	13	4968
St. Louis, Mo.	19	3	4187
Salt Lake City, Utah	72	73	6406
Sandusky, Ohio	17	18	5405
San Francisco, Calif.	206	154	2609
Sault Ste. Marie, Mich.	185	94	8516
Scranton, Pa.	29	49	5615
Seattle, Wash.	155	94	4258
Sioux City, Iowa	36	51	6468
Spokane, Wash.	184	115	6614
Springfield, Ill.	25	0	4778
Springfield, Mo.	29	9	4507
Syracuse, N. Y.	49	50	6328
Tacoma, Wash.	193	122	4663
Terre Haute, Ind.	16	2	4653
Toledo, Ohio	30	23	5657
Trenton, N. J.	14	29	4723
Utica, N. Y.	50	77	6647
Washington, D. C.	1	8	2901
Wichita, Kan.	16	3	4499
Yakima, Wash.	93	51	5465

Figures in this table, with eight exceptions, are calculated by HEATING AND VENTILATING from local weather bureau reports. Exceptions are Utica, Lewiston, Kewanee, and Sioux City, figures for which are furnished through the courtesy of Coke Sales Department, Central New York Power Corp., Utica, N. Y.; Norman E. Ross, Bursar, Bates College, Lewiston, Me.; J. M. Hartman, Engineering Department, Kewanee Boiler Corp., Kewanee, Ill., and Alfred R. Wagstaff, Engineer, Sioux City Foundry and Boiler Co., Sioux City, Iowa, respectively; Anaconda, Bozeman, Butte and Livingston, Mont., through the courtesy of the Montana Power Company. HEATING AND VENTILATING will welcome an opportunity to make arrangements with readers who are keeping degree-day records over a period for important communities not listed above in order to make such data available to the industry.

*These figures are for May, 1942: May, 1941: and Season 1941-42 to May 31, respectively.

NEW CATALOGS

HEATER COMPARISONS

Dravo Corporation
302 Penn Avenue, Pittsburgh, Pa.

A multigraphed, 13-page binder assembly entitled "More Man-Hours — Materials — Money," which gives comparative costs and operating data between the company's various types of heating units and competitive conventional types showing savings possible in critical materials and labor.

CENTRIFUGAL PUMPS AND COMPRESSORS

Worthington Pump and Machinery Corporation
Harrison, N. J.

A four-page bulletin W-312-B2C describing and illustrating the company's single stage volute type L (Nos. 3 to 6) centrifugal pumps. Complete specifications and dimensions are given, as well as sectional views illustrating inner workings of the pumps. A six-page specification folder L-640-S2 on single stage horizontal types HB and HS compressors with strokes of 9, 11, and 13 inches. Includes a table of general data.

CONDITIONERS

Carrier Corporation
Syracuse, New York

A standard size 12-page catalog giving condensed information on air conditioning, refrigeration and special heating equipment. Includes typical applications and ratings.

BELT VULCANIZERS

B. F. Goodrich Company
Akron, Ohio

A standard size four-page folder, catalog section 2158 gives dimensional and performance data of the company's line of belt vulcanizers for splicing and repairing rubber impregnated belts.

METAL WORKING

Joseph T. Ryerson & Son, Inc.
2558 West 16th Street, Chicago, Ill.

A 96-page catalog No. 42 listing cutting, bending, grinding and punching machines for use in metal fabricating and general maintenance operations. Specifications, illustrations and performance data shown in detail.

PUMPS

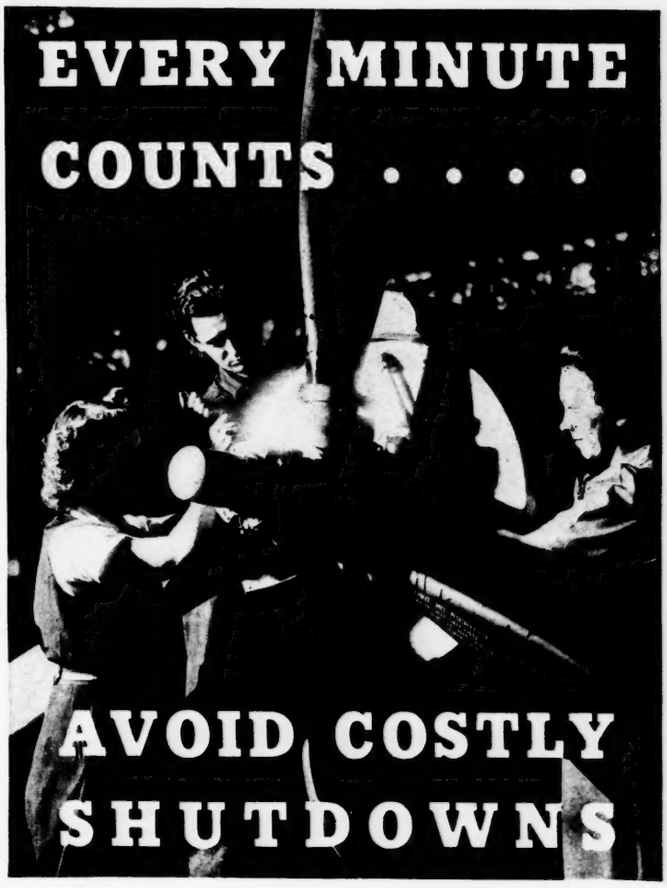
Worthington Pump and Machinery Corporation
Harrison, N. J.

Data sheet W-310-B11 gives specifications and ratings of the company's type CY single stage, open impeller, belt or motor driven centrifugal pumps.

INSTRUMENTS

Roller-Smith Company, Bethlehem, Penna.

Standard size 12-page catalog 4220 describes and illustrates the company's line of ac and dc instruments for switchboard mounting. These include ammeters, voltmeters, synchroscopes, and others.

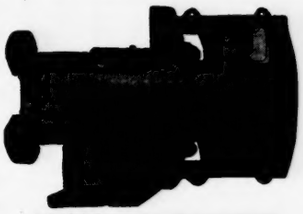


—*Photo courtesy of Curtiss-Wright Corp.*

● Every minute counts at Socony-Vacuum Oil Co., Goodyear Tire & Rubber Co., Chrysler, Carnegie-Illinois Steel, DuPont and other war industries where ADSCO Piston-Ring Expansion Joints safeguard steam lines against costly shutdowns.

These are the only slip type joints that can be unpacked and repacked under full operating conditions, without interruption to service.

Piston rings in the internal guide hold the line pressure during unpacking and repacking operations. ADSCO Piston-Ring Expansion Joints are FULLY GUIDED by internal and external guides. Available in single or double joints for high pressure and high temperatures; flanged or beveled ends. Write for Bulletin 35-15V.

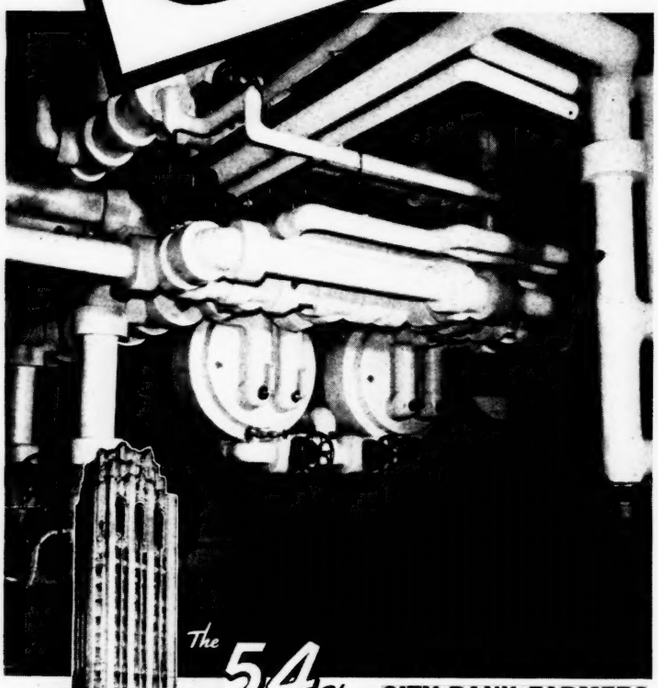


ADSCO PISTON-RING EXPANSION JOINT
FOR STEAM, HOT WATER, OIL OR GAS LINES

AMERICAN DISTRICT STEAM COMPANY NOR H TONAWANDA, N. Y.
MAKING "UP-TO-DATE" STEAM LINE EQUIPMENT FOR OVER 60 YEARS

INSTALL ADSCO PISTON RING JOINTS
CAN BE PACKED UNDER PRESSURE

HEATING SYSTEM
CITY BANK FARMERS
TRUST COMPANY
BUILDING
Carey INSULATED



The 54 Story CITY BANK FARMERS TRUST COMPANY BUILDING
NEW YORK

—an outstanding example of efficiency in distribution of heat and hot water. Heat loss was cut to the minimum by insulating all steam and hot water pipe with CAREY 85% Magnesia—the insulation of better performance and greater resistance to breakage. Insulation contractors — Robert Keasbey Co., New York City.

When you want real results, with permanence, rely on CAREY. For details, address Dept. 49.

THE PHILIP CAREY MFG. COMPANY
Dependable Products Since 1873
Lockland, CINCINNATI, OHIO
In Canada: The Philip Carey Company, Ltd.
Office and Factory: Lennoxville, P. Q.

BOILER CONVERSION

National Radiator Company
221 Central Ave., Johnstown, Pa.

In the New Catalog Section of the July issue the description of National Radiator Company's catalog was in error in that the last sentence read "detailed are all parts and prices necessary for the change-over of the company's existing coal-fired boilers during the emergency." It should have read "Detailed are all parts and prices necessary for the change-over of the company's boilers during the emergency."

STEAM EJECTORS

Worthington Pump and Machinery Corporation
Harrison, N. J.

Standard size, 6-page bulletin W-205-B7A gives descriptive matter and engineering data on the company's line of steam-jet ejectors of the two-stage condensing type, used for producing high vacuum in industrial processes.

CONTROLS

Barber-Colman Company, Rockford, Illinois

A standard size 36-page temperature control catalog discussing motor-operated valves, control motors, thermostats, humidity controllers, program switches, and other accessories used in heating, ventilating, air conditioning and industrial applications.

MECHANICAL DRYERS

McNally Pittsburg Mfg. Corporation
307 N. Michigan Avenue, Chicago, Ill.

Bulletin No. 242, 8 pages, standard size, explains and illustrates the operating and construction features of the McNally-Vissac heat dryers for handling coal or other granular material.

CONDENSATION EQUIPMENT

Ames Hydrovac Corporation
290 Scholes Street, Brooklyn, N. Y.

Two new standard size 4-page bulletins describing the company's line of condensation handling units. Bulletin No. 100-A deals with vacuum return units. Bulletin No. 200 covers gravity type return units.

PRESSURE RECORDERS

Foxboro Company, Foxboro, Mass.

New catalog 22-A, 32 pages, covering the company's instruments for the measurement and recording of industrial pressures of all kinds in ranges from 1 inch of water to 20,000 lb. A complete list of standard ranges is given, accompanied by full-size reproductions of specimen charts.

STRAINERS

Yarnall-Waring Company
Chestnut Hill, Philadelphia, Pa.

A four-page standard size bulletin S-200 describing and illustrating strainers for pipe lines. Includes a table of prices, weights, and dimensions with typical applications shown.

VALVES

The Fairbanks Company
393 Lafayette Street, New York, N. Y.

A standard size, 6-page folder giving complete installation details and working data for the new line of Faircoseal bronze valves which employ silver brazed joints in place of soldered or gasketed joints.

WITH THE MANUFACTURERS

THE CELOTEX CORPORATION

has opened new general offices at 120 South LaSalle Building, Chicago. The offices were moved from the Palmolive Building where they have been located since 1929.

PENN ELECTRIC SWITCH CO.

has moved its Boston branch to 50 Hunt St., Watertown, Mass. A. W. Barr continues as branch manager.

SEAMLEX COMPANY, INC.

has moved into an enlarged plant and main offices at 27-27 Jackson Ave., Long Island City, N. Y.

PERSONALS AND PERSONNEL

UNITED STATES RADIATOR CORPORATION

of Detroit, Michigan, has elected W. E. Mosher as president to succeed the late Elwood S. White. J. F. McIntire was elected first vice-president. Mr. McIntire was also elected president of the Pacific Steel Boiler Corporation to succeed Mr. White in that position.

ROBERT L. COE

Robert L. Coe, vice-president of Chase Brass & Copper Co., Inc., was elected president of the Copper & Brass Research Association at its twenty-second annual meeting held May 22. He succeeds John A. Coe, president of The American Brass Company.

JAMES C. TWEEDELL

export manager of the York Ice Machinery Corporation, has been appointed general sales manager for the duration, succeeding John R. Hertzler, who has undertaken a special assignment in a civilian capacity with the Army-Navy munitions board in Washington. Mr. Tweedell, a graduate of Rhode Island State College, has been with York since 1924, and has previously been assistant manager of the industrial division and manager of the commercial division. He has been manager of the Export division with headquarters in New York City, since 1935. Prior to the war much of his time was spent abroad, in connection with the activities of York's overseas organization.

F. R. HOLDEN

Francis R. Holden, a specialist in healthful working conditions, has been appointed industrial hygienist on the staff of Industrial Hygiene Foundation, Mellon Institute, Pittsburgh. He will assist companies associated with the Foundation in controlling employee health hazards which are increasing with peak war production.

JAMES CROMBIE

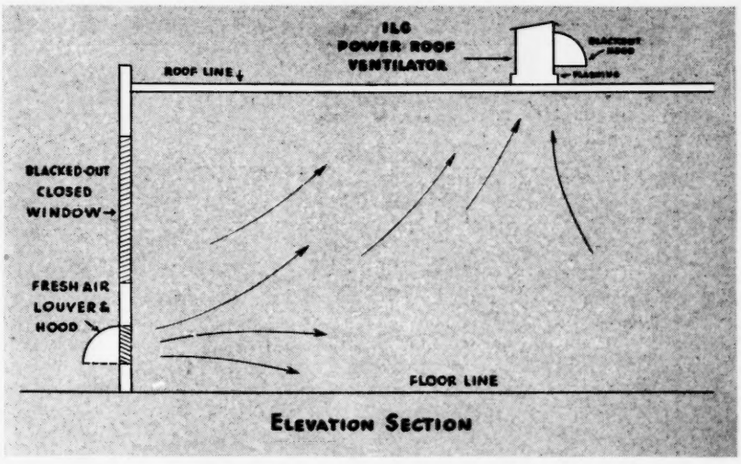
long affiliated with the heating and air conditioning field, working out of Cincinnati, has become associated with C. A. Olsen Mfg. Co., Elyria, Ohio. Mr. Crombie's headquarters will be in Elyria.

How to Engineer

Simple, Effective, Low-Cost

BLACKOUT VENTILATION

As windows are blacked-out and closed in war-crowded plants and offices, adequate ventilation becomes a *"must"!* Excessive heat, "worn-out" air, odors, smoke, steam, dust, fumes, etc., *must* be rapidly removed . . . fresh, invigorating air *must* be supplied to speeding workers . . . without transmitting light! To help you solve this modern problem, Ilg has developed the simple, effective, low-cost system illustrated below which not only handles emergency ventilation today, but will be in operation long years hence for normal air change requirements.



ELEVATION SECTION

FREE . . . BLACKOUT BULLETIN!

New Bulletin No. 304 gives you the complete story . . . get it today. If you are faced with a specific job right now, write, wire or phone for dimension drawings on blackout hoods (to be quickly, easily fabricated on location) for standard Ilg Power Roof Ventilators, also Fresh Air Inlets.

ILG ELECTRIC VENTILATING CO., 2858 N. CRAWFORD AVE., CHICAGO, ILL.
OFFICES IN 40 PRINCIPAL CITIES CONSULT YOUR PHONE DIRECTORY

ILG

Vitalized Ventilation

AND AIR CONDITIONING

AIR CHANGE . . . NOT JUST AIR MOVEMENT!

To our many friends who have helped make our first 50 years successful

we wish to thank you for your support in the past and to express the hope that we may have the privilege of serving you in the years to come.

THE POWERS REGULATOR COMPANY

Offices in 47 Cities

50 Years of Automatic Temperature and Humidity Control

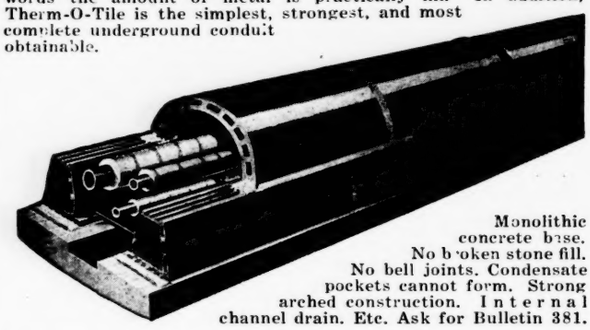
THERM-O-TILE

Reg. U. S. Pat. Off.

SAVES METAL

Help win the war by enclosing your underground pipe lines in efficient non-metallic Therm-O-Tile

Pipe supports and saddles require the **only** metal in Therm-O-Tile —an exceedingly important advantage right now. In other words the amount of metal is practically nil. In addition, Therm-O-Tile is the simplest, strongest, and most complete underground conduit obtainable.



Monolithic concrete base. No broken stone fill. No bell joints. Condensate pockets cannot form. Strong arched construction. Internal channel drain. Etc. Ask for Bulletin 381.

Sold and installed by Johns Manville Construction Units in all Principal Cities. See our page in Sweet's or The Heating Guide.

H. W. PORTER & CO., Inc.

823-V Frelinghuysen Ave., Newark, New Jersey

Without obligating us in any way, ☐ Please send Bulletin 381. ☐ Send representative. ☐ Enclosed is a sketch, with principal data of a prospective job, on which we shall be glad to have your ☐ comments, ☐ quotations.

Write your name, firm, and address on the margin of this page, tear out with the checked squares above, mail, and you will hear from us promptly.

C. GRANNISS BONNER

formerly comptroller and more recently treasurer of The Brunswick-Balke-Collender Company of Chicago, has been elected treasurer of Pomona Pump Co., Pomona, California.

SUMMER DEGREE HOURS (Above 85F) JUNE, 1942

There is some evidence that the summer air conditioning load in residences is roughly proportional to the number of summer degree hours above 85F. For that reason HEATING AND VENTILATING has been compiling and recording these data for a number of years. The following table covers these data for June, 1942

City	Number of Degree-Hours June, 1942	Number of Degree-Hours, Summer, 1942, to June 30
Baltimore	147	259
Birmingham	478	597
Bismarck	0	5
Boston	61	73
Buffalo	12	12
Chicago	69	221
Cincinnati	156	217
Cleveland	97	121
Columbus	242	333
Des Moines	202	260
Detroit	38	82
Fort Wayne	77	180
Houston	706	855
Indianapolis	278	381
Memphis	772	900
Milwaukee	19	22
Minneapolis	15	15
New Orleans	503	589
New York	3	24
Oklahoma City	504	627
Philadelphia	93	152
Pittsburgh	46	97
Portland, Ore.	157	157
Richmond, Va.	335	523
St. Louis	371	453
San Francisco	2	9
Savannah	546	671
Toledo	95	176
Washington	181	380

These figures are computed from data made available through the cooperation of the U. S. Weather Bureau.

COMING EVENTS

NOV. 30—DEC. 5. 15th National Exposition of Power and Mechanical Engineering at the 1942 National Power Show to be held at Grand Central Palace. Management is by International Exposition Co., headquarters at Grand Central Palace, New York.

H&V's PHOTOS

Front Cover—Weber Showcase and Fixture Co., Los Angeles, Calif.
Page 19—U. S. Army Signal Corps.
Page 20—(Second from top) U. S. Army Signal Corps.
Pages 21-22—Walter T. Abbott, Boston.
Page 23—Hedrich-Blessing Studio, Chicago.
Page 24—Swallow's Studio, Philadelphia.
Pages 28-29—Figs. 3 and 4 from Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa.
Pages 26-28—Figs. 1 and 2 from General Electric Company, Schenectady, N. Y.

HEATING AND VENTILATING

The Air Conditioning Monthly